Route Engineering Assessment of the

Skeena–Rupert

High Voltage Transmission Line

B.C. Hydro

86-06751/

Canadian Cataloguing in Publication Data

Main entry under title:
Route engineering assessment of the Skeena-Rupert high voltage transmission line

"Report no. TP 1041"
ISBN 0-7719-9194-0

1. Electric lines - British Columbia. 2. Electric power transmission - British Columbia. I. B.C. Hydro. Transmission Projects Division.

TK3144.R68 621.319'13 C83-092129-X

ROUTE ENGINEERING ASSESSMENT
OF THE
SKEENA-RUPERT
HIGH VOLTAGE TRANSMISSION LINE

B.C. HYDRO

B.C. HYDRO

ROUTE ENGINEERING ASSESSMENT
OF THE
SKEENA-RUPERT
HIGH VOLTAGE TRANSMISSION LINE

TRANSMISSION PROJECTS DIVISION

FEBRUARY 1983

ER70

Report No. TP 1041

ROUTE ENGINEERING ASSESSMENT

OF THE

SKEENA-RUPERT

HIGH VOLTAGE TRANSMISSION LINE

CONTENTS

Section	Subject	Page
	PREFACE	iii
	SUMMARY	iv
1.0	INTRODUCTION	
	1.1 Purpose and Scope	1 - 1
	1.2 Study Area	1 - 2
2.0	PROJECT DETAILS	
	2.1 Preliminary Project Schedule	2 - 1
	2.2 Design Information	2 - 2
3.0	DELINEATION AND REFINEMENT OF ROUTE OPTIONS	
	3.1 General	3 - 1
	3.2 Initial Route Options	3 - 1
	3.3 Unacceptable Route Options	3 - 2
	3.4 Acceptable Route Options	3 - 4
4.0	ROUTE DESCRIPTIONS	
	4.1 General	4 - 1
	4.2 Skeena River Route	4 - 2
	4.3 Douglas Channel Route	4 - 14
5.0	ROUTE EVALUATION	
	5.1 Introduction	5 - 1
	5.2 Technical Evaluation	5 - 2
	5.3 Cost Estimates	5 - 9
	5.4 Hazard Evaluation	5 - 11
	5.5 Segment Comparison	5 - 21
6.0	CONCLUSIONS AND RECOMMENDATIONS	
	6.1 Conclusions	6 - 1
	6.2 Recommendations	6 - 5

CONTENTS - (Cont'd)

TABLES

Table No.	
5-1	Technical Evaluation Criteria
5-2	Technical Evaluation
5-3	Segment Cost Estimates - Scheme 1
5-4	Segment Cost Estimates - Scheme 2
5-5	Hazard Evaluation Criteria
5-6	Hazard Evaluation

FIGURES

Figure No.	
1-1	Study Area
2-1	Preliminary Project Schedule
2-2	Typical 500 kV Lattice Steel Tower Outlines
2-3	Typical 287 kV Steel Tower and Woodpole Structure Outlines
2-4	Preliminary Right-of-Way Cross Sections - Scheme 1 (Sh. 1-4)
2-5	Preliminary Right-of-Way Cross Sections - Scheme 2 (Sh. 1-4)
3-1	Initial Route Options
3-2	Refined Route Options
4-1	Skeena River Route
4-2	Douglas Channel Route
5-1	Skeena River Route - Avalanche Hazard Areas
6-1	Technically Preferred Route

APPENDICES

Appendix No.	
I	DESIGN AND CONSTRUCTION PROCEDURES

PREFACE

B.C. Hydro is planning an additional high voltage transmission line from Skeena Substation near Terrace to Rupert Substation near Prince Rupert for an in-service date in 1988.

This report, prepared by the Route Engineering Department of B.C. Hydro, examines all technically feasible routes with emphasis on transmission line design, construction, cost and security. The report has been prepared in accordance with the Guide to the Energy Project Review Process published by the Ministry of Energy, Mines and Petroleum Resources in 1982.

An environmental report entitled "Skeena-Rupert 500 kV Transmission Line Environmental and Socio-Economic Assessment" has been prepared by the Environmental and Socio-Economic Services Department of B.C. Hydro and is available as a companion document. The environmental report provides detailed information on the potential impacts of the transmission line and possible mitigation measures.

A planning report for this project entitled "Skeena-Rupert 500 kV Transmission Line Preliminary Planning Report" has been prepared by the System Planning Department of B.C. Hydro. It discusses project justification and planning.

Following discussion of the project and routing possibilities with the public and government agencies, a preferred route will be determined and an application will be prepared for an Energy Project Certificate under the B.C. Utilities Commission Act.

A public consultation program will begin with the release of this and other reports on the proposed Skeena-Rupert transmission line. Anyone wishing further information on this project is invited to contact the Community Relations Department, B.C. Hydro, 970 Burrard Street, Vancouver, B.C. V6E 1Y3 or telephone 663-4344 (collect if long distance).

SUMMARY

This report summarizes the results of an investigation of possible routes for two transmission schemes either of which would provide a necessary increase in firm power supply to the Prince Rupert area. At present the major means of power supply to the Prince Rupert area is a 287 kV line between Skeena and Rupert substations. The two schemes are as follows:

1. Scheme 1 - A single 500 kV transmission line between Skeena and Rupert substations with an in-service date of 1988.

2. Scheme 2 - A single 287 kV transmission line between Skeena and Rupert substations with an in-service date of 1988 followed by another 287 kV line in the late 1990's between Kitimat substation and Rupert substation.

Six major route options were considered at the beginning of the study, four originating at Skeena Substation and two at Kitimat Substation. The routes originating at Skeena Substation include the Skeena River route which follows the Skeena River valley and Highway 16. The other three cross the middle and upper reaches of the Exstew, Exchamsiks and Khyex river valleys to Work Channel and then follow the Prudhomme valley to Rupert Substation. These are named Mt. Campagnolo, Exstew and Kasiks routes respectively.

The Douglas Channel route originates at Kitimat Substation and follows Douglas Channel to Kitkiata Inlet and then along the Quaal and the Ecstall rivers to Tyee. From here it follows Highway 16 to Rupert Substation. The Little Wedeene route follows the Little Wedeene, Gitnadoix, Khtada, and Skeena valleys to Rupert Substation.

The Mt. Campagnolo, Exstew, Kasiks and Little Wedeene routes were eliminated from further study after field investigations revealed that transmission line security could not be obtained due to severe terrain hazards along sections of the routes.

The Skeena River and Douglas Channel routes were divided into various segments and evaluated from technical, cost and hazard perspectives.

The investigation concludes that the most technically suitable route for Scheme 1 is the Skeena River route, generally following the existing 287 kV transmission line on the south side of the Skeena valley. The exceptions are some sections which generally parallel the CNR and Highway 16 on the north side of the river between Shames and Salvus and along the Lachmach and Prudhomme valleys. Severe avalanche, river erosion and ice hazards warrant separating the proposed transmission line from the existing line in these areas.

The most technically suitable route for the initial circuit in Scheme 2 is the same route recommended for Scheme 1. The Douglas Channel route is recommended for the subsequent 287 kV circuit.

SECTION 1.0 - INTRODUCTION

1.1 PURPOSE AND SCOPE

At present the major means of power supply to the Prince Rupert area is a 287 kV transmission line. This line follows the Skeena River valley and Highway 16 from Skeena Substation near Terrace to Rupert Substation located on Morse Basin 10 km southeast of Prince Rupert. Minor sources of power supply in the area include the 7 MW Falls River Generating Station and two 23 MW standby gas turbine generators.

Severe climatic conditions and hazardous terrain are characteristic of the existing transmission route between Terrace and Prince Rupert. The existing line has withstood these conditions well but failures, when they occur, can be severe. An extended outage of the line leaves customers in Prince Rupert dependent on the limited local generation which is inadequate to serve all load in the area now and will be unable to serve even the non-industrial load after 1987. Furthermore, after 1988, it is expected that load at Prince Rupert will have grown to the point where it exceeds the capability of the existing 287 kV line. Increased security and additional transmission capacity can be obtained by one of two transmission schemes:

1. Scheme 1 - A single 500 kV circuit from Skeena substation to Rupert substation.

2. Scheme 2 - Two additional 287 kV circuits to Rupert substation, one from Skeena Substation, the other from Kitimat Substation.

This report considers possible transmission line routes for each of these schemes. [Note: the term "route" as used in this report is defined as a "linear area of land of indeterminate width within which

one or more right-of-way alignments could be located" as per ELUC Guidelines for Linear Development (1977).]

The most feasible routes are evaluated and compared on the basis of design, construction, cost, maintenance and hazard criteria leading to a recommendation of the most preferred route from a technical perspective. No attempt is made to define the precise centreline alignment along the recommended route.

The environmental and social aspects of the recommended route are discussed in a separate report as outlined in the Preface.

1.2 STUDY AREA

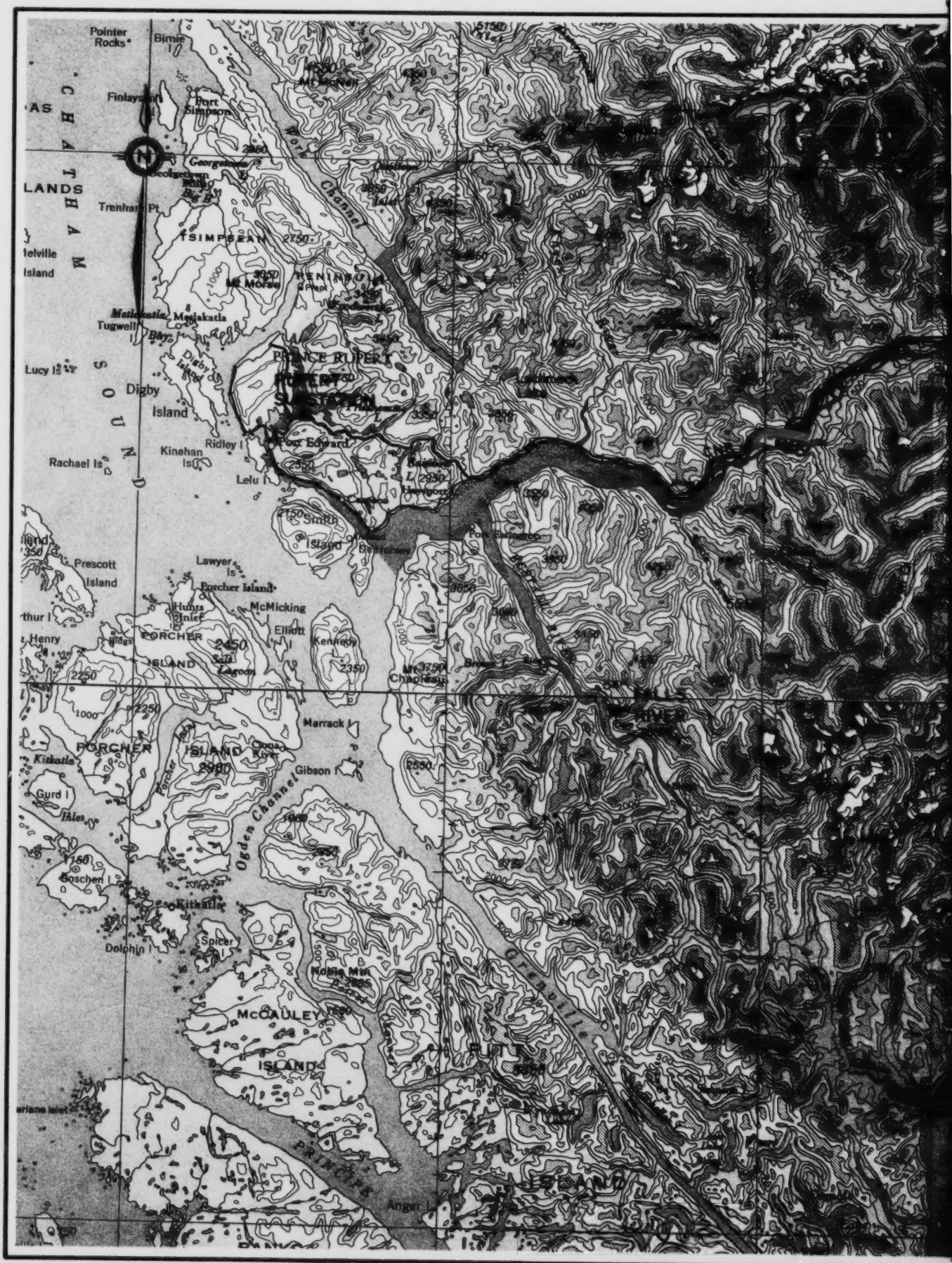
The study area encompasses approximately 6000 km^2 primarily within the Kitimat Ranges of the Coast Mountains. With reference to Fig. 1-1 it can be roughly defined as a large triangular shaped area whose northern boundary extends westward from Terrace to Mt. Campagnolo and southwestward to Prince Rupert. The southwestern boundary extends from Prince Rupert along the Ecstall and Quaal rivers to Kitkiata Inlet on Douglas Channel. Douglas Channel and the Kitimat River valley form the southeastern boundary. Skeena, Rupert and Kitimat substations form the fixed points within the study area.

The major terrain feature within the study area is a set of northwesterly trending valleys essentially parallel to the coastline. The more prominent of these features include Work and Grenville channels and the Ecstall River valley. There are numerous but less prominent and continuous northwesterly trending valleys to the east. Examples include the Khyex, Exchamsiks and Exstew valleys north of the Skeena and the Quaal, Scotia and Khtada valleys to the south. These valleys are generally short and terminate in icefields.

A second set of valleys exist which are at right angles to the first and run transverse to the direction of the coastline. These are far less numerous but are more prominent and continous. They include the Skeena River valley, Douglas Channel and Kitimat Arm.

The terrain between the major valleys consists of extremely rugged and continuous mountain ranges approaching 1000 m to 2000 m in elevation. Numerous permanent icefields and glaciers exist at elevations as low as 1000 m, drained by short creeks and rivers with steep gradients. Most valley walls exceed 35° in slope and are avalanche swept.

Treeline is approximately at El. 750 m due primarily to the severe climatic conditions in the area. In more exposed areas, particularly northeast facing slopes along Douglas Channel, treeline is only a few hundred metres above sea level.


Pointer Rocks
Birnie I
Finlayson I
Port Simpson
Work Channel
Georgetown
Trenhan Pt
SIMPSEAN
Melville Island
Mt Morse
HENINGA
Metlakatla
Tugwell I
Lucy Is
Digby Island
PRINCE RUPERT
Kinahan Is
Ridley I
Rachael Is
Lelu I
Smith Island
Prescott Island
Lawyer Is
Porcher Island
McMicking
Hunts Inlet
Elliott I
Kennedy
PORCHER ISLAND
Salt Lagoon
Mt Chapleau
Marrack I
Kitkatla
Gibson I
Gurd I
Ogden Channel
Goschen I
Dolphin I
Spicer I
McCAULEY ISLAND
Grenville Channel
Anger I
PRINCE OF WALES ISLAND
SOUND
CHANNEL

KEY PLAN

ELEVATIONS IN FEET

SCALE 1:500,000

Kilometres 10 0 10 20 30

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE STUDY AREA

DATE	FIG. 1-1
DWN	DWG. No.

REPORT No.

SECTION 2.0 - PROJECT DETAILS

2.1 PRELIMINARY PROJECT SCHEDULE

The project schedule as presently proposed is shown on Fig. 2-1. The first phase of the project, project assessment studies, is presently underway. This includes project planning and engineering and environmental route selection studies. These are being documented for use in the public consultation stage and to facilitate government review during the Energy Project Review process. In order to meet the in-service date, route approval is required by 31 March 1984. Other planning and development activities will be undertaken in 1983 and 1984 including specialized design studies and an assessment of access and construction requirements.

Centreline surrey will be carried out in 1983 and 1984 in order to establish a precise centreline alignment.

The right-of-way clearing boundaries are scheduled to be flagged in 1983 and 1984. Logging, where necessary, would take place in 1984 and 1985 and the right-of-way would be cleared in 1985 and 1986.

The installation of foundations and structure erection is scheduled for 1986 and 1987. Conductor stringing is to be carried out in 1988. The presently scheduled in-service date is November 1988.

The project schedule is preliminary only and may be modified to suit the particular scheme selected and the conditions encountered along the route. It is expected that the main field activities would probably take place from late March to late October because of wet conditions,

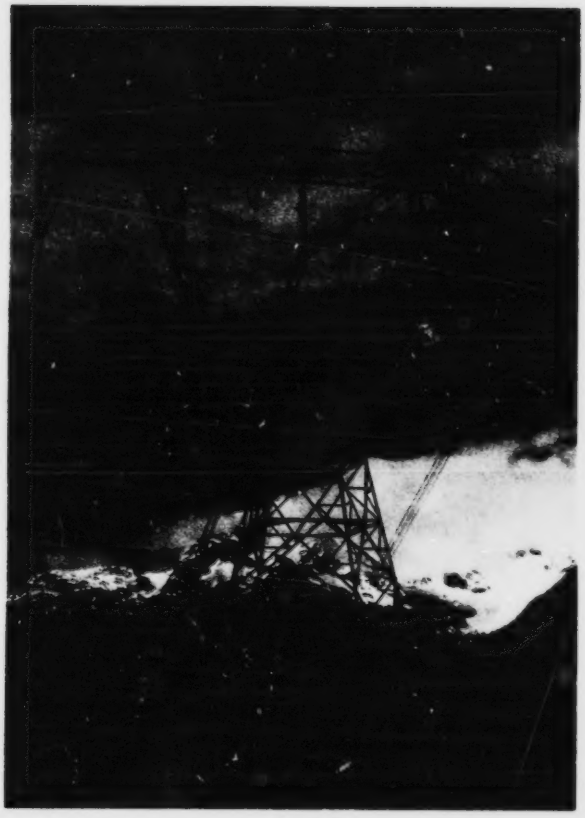


PHOTO 2-1 — Typical 500 kV self supporting suspension tower.

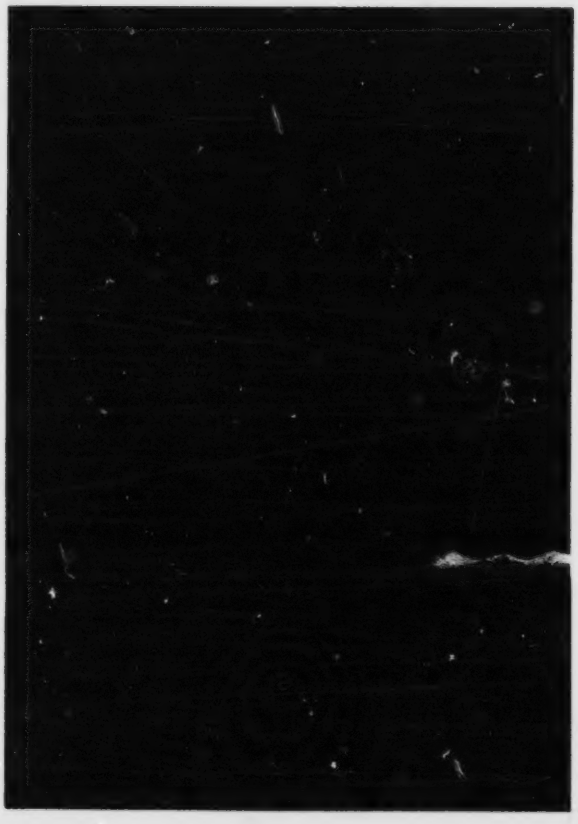


PHOTO 2-2 — Typical 500 kV guyed suspension tower.

low temperatures, river ice and high avalanche danger during the winter months. Construction activities may be disrupted in the spring by high water conditions along the major rivers and in the fall by "flash" flooding particulary along some of the major tributary creeks and rivers.

2.2 DESIGN INFORMATION

(a) Structures

1. Scheme 1 - It is presently proposed that existing 500 kV structure designs will be utilized for the project. The majority of the structures would be self-supporting steel lattice structures (Photo 2-1) due to rugged terrain and hazardous conditions. Some guyed lattice steel suspension structures (Photo 2-2) would be used in relatively easy, terrain where there is little avalanche, icing or erosion hazard.

   The 500 kV structure types are also illustrated on Fig. 2-2.

2. Scheme 2 - The proposal for this scheme is to utilize 287 kV construction similiar to the existing line. Self-supporting steel lattice structures would be utilized in rugged, hazardous terrain. H-frame wood pole structures would be utilized in easier terrain.

   The 287 kV structure types are illustrated on Fig. 2-3.

(b) Foundations

Foundations for 287 kV and 500 kV steel structures are generally similiar except for the dimensions. The steel lattice towers are supported by three general foundation types. These include grillages, rock and pile footings.

Grillages are used for most earth footings. They are pyramid shaped and are constructed of bolted steel. The size of the grillage varies depending on the size of the tower and the load it will have to support. Grillages are set to depths of 2 m to 4 m at each tower leg and are backfilled and compacted.

Earth anchors for 500 kV guyed structures generally consist of a piece of steel channel varying in length from 1 to 3 m which is embedded in approximately 1 m of concrete at depths of 1 to 3 m. The steel channel is connected to the guy wire by a means of a steel rod which varies in length depending on ground slope. The anchor assembly is subsequently backfilled.

Rock footings consist of small concrete pedestals which are anchored to the rock with rock bolts and are grouted in place.

Pile footings designed for swampy ground consist of large timber or concrete piles which are driven to varying depths. The piles are then capped with a concrete pedestal.

Footings for wood pole structures are simpler than those required for steel structures. The poles are set in the ground to a depth of approximately 10 percent of their length. The hole is back-filled and compacted with the native material or imported gravel.

Specialized foundations and protective devices are used to protect against various hazards.

(c) Conductor

(i) Scheme 1: 500 kV

For preliminary design purposes it is proposed that a four conductor bundle of 48/7 ACSR "Peace" conductor be used. Each conductor would have a cross-sectional area of 316 mm^2 and a bare weight of 1.09 kg/m.

(ii) Scheme 2: 287 kV

It is proposed that two types of conductor be used for this scheme. For the steel tower section a single 54/19 ACSR "Grackle" conductor with a cross sectional area of 604.3 mm^2 and a bare weight of 2.27 kg/m would be used.

The conductor proposed for the wood pole section is a single 61/0 ASC "Columbine" conductor with a cross sectional area of 684.8 mm^2 and a bare weight of 1.89 kg/m.

Stronger conductor may be required for long spans and heavy ice and wind loading areas.

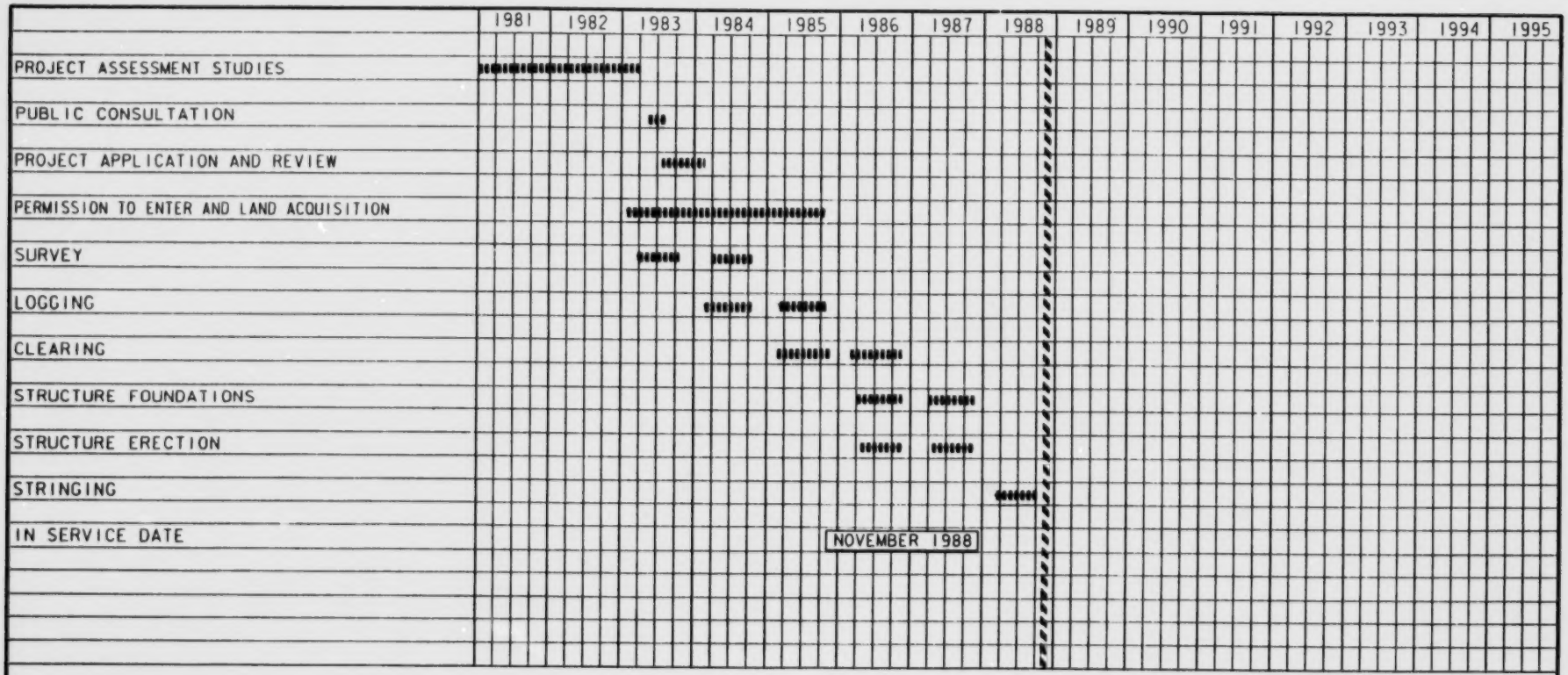
(d) Right-of-Way

Preliminary right-of-way cross sections are shown on Figs. 2-4 and 2-5. These show typical right-of-way widths and circuit to circuit separation. Right-of-way widths would increase at longer spans or where otherwise dictated by local conditions.

The average span length for the 500 kV scheme would be in the order of 400 m resulting in approximately 2.5 towers per kilometre.

The average span length for the 287 kV scheme would be 350 m for the steel tower sections resulting in approximately 2.9 towers per kilometre. The 287 kV wood pole span lengths are shorter at approximately 230 m resulting in approximately 4.3 structures per kilometre.

The span lengths will vary depending on the topography along the centreline.



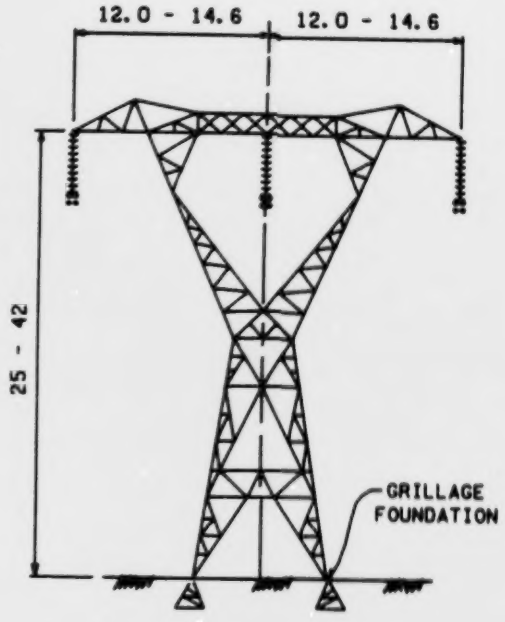
NOTES:

1. THE SCHEDULE OF ACTIVITIES AS INDICATED WOULD BE SIMILAR FOR BOTH 500 kV AND 287 kV CONSTRUCTION (SCHEMES 1 & 2)
2. SCHEDULE FOR SECOND 287 kV LINE (SCHEME 2 - 1997 IN SERVICE) NOT INDICATED.

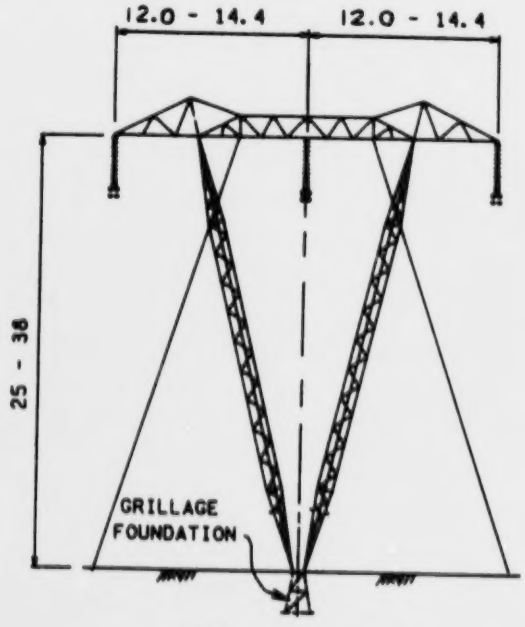
BC Hydro

SKEENA-RUPERT
HIGH VOLTAGE TRANSMISSION
LINE
PRELIMINARY SCHEDULE
(SCHEMES 1 & 2 1988 IN SERVICE)

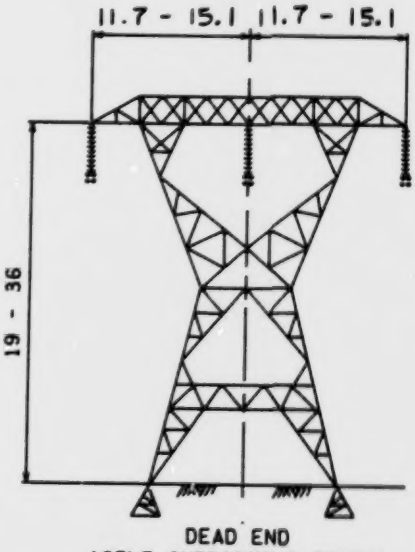
DATE	FIGURE 2.1
DRAWN	DWG. NO



TANGENT & LIGHT ANGLE
(SELF SUPPORTING TOWER)



TANGENT & LIGHT ANGLE
(GUYED TOWER)



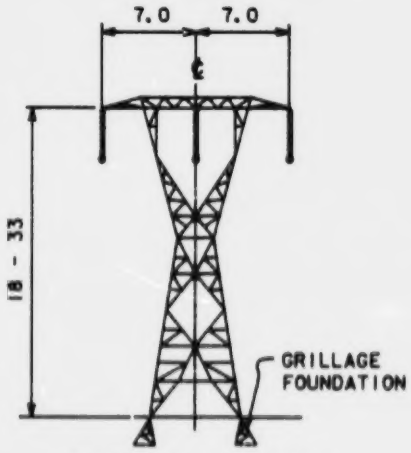
DEAD END
(SELF SUPPORTING TOWER)

NOTE:

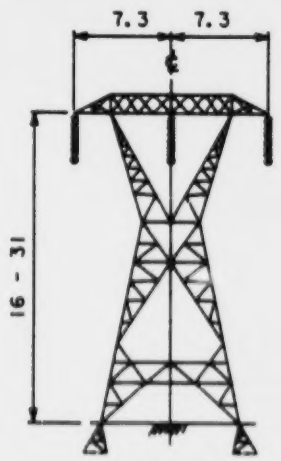
ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE TYPICAL 500 kV LATTICE STEEL TOWER OUTLINES	
DATE	FIGURE 2 - 2
DWN.	DWG. No.

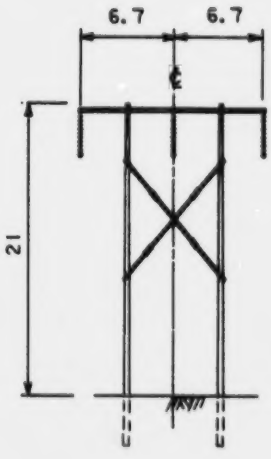
A



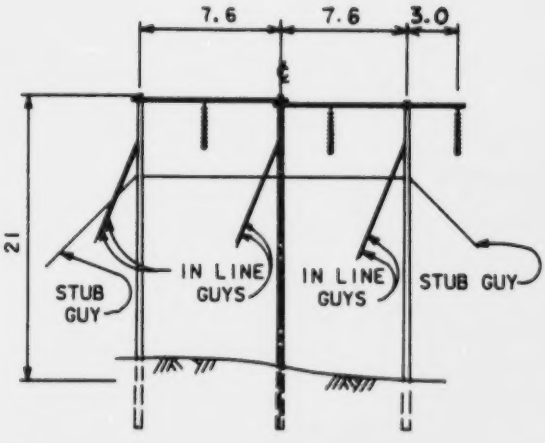
TANGENT & LIGHT ANGLE
(SELF SUPPORTING TOWER)



DEAD END
(SELF SUPPORTING TOWER)



TANGENT & LIGHT ANGLE
(WOOD POLE STRUCTURE)



DEAD END
(WOOD POLE STRUCTURE)

NOTES:

1. WOOD POLE HEIGHTS ARE AVERAGE ONLY.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

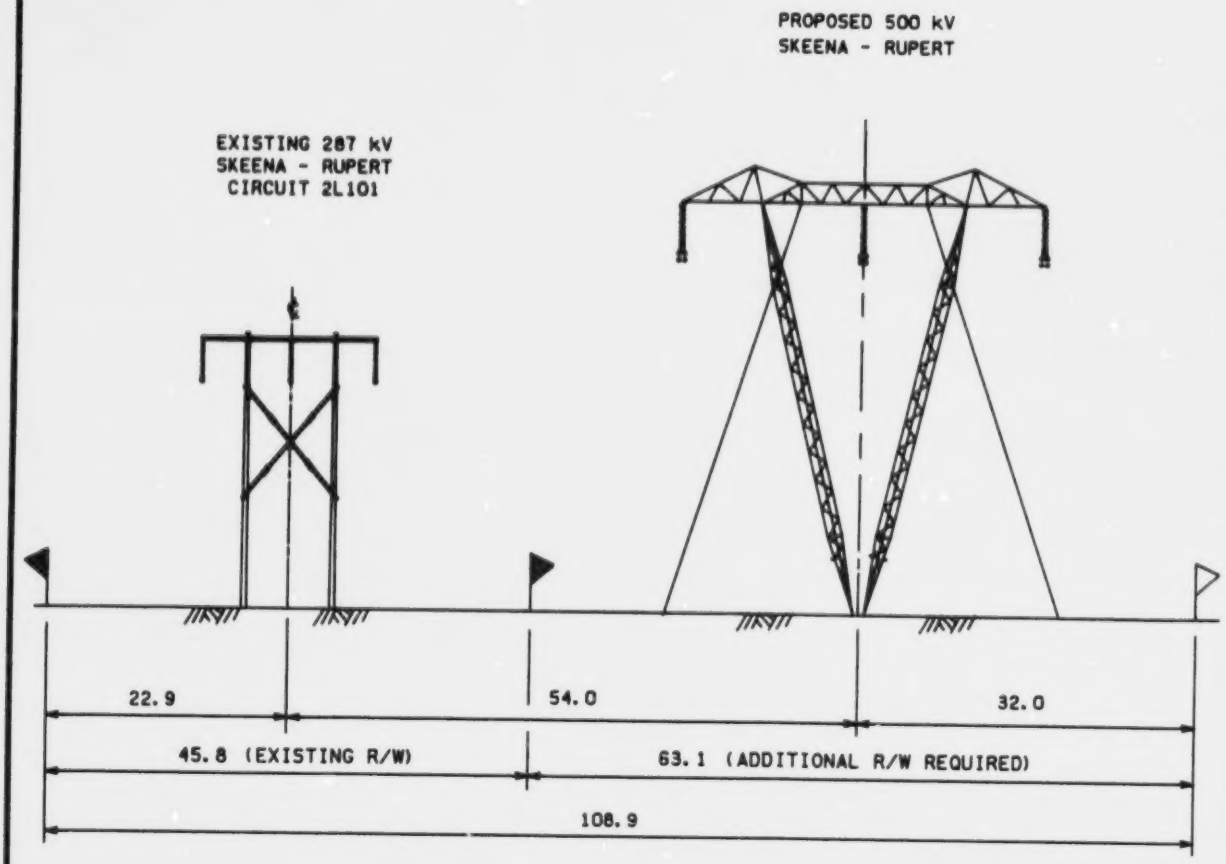
SKEENA - RUPERT

HIGH VOLTAGE TRANSMISSION LINE

TYPICAL 287 kV LATTICE STEEL TOWER AND WOOD POLE STRUCTURE OUTLINES

DATE	FIGURE 2 - 3
DWN.	DWG. No.

A



VIEW LOOKING TOWARDS RUPERT SUBSTATION (SEGMENT SK1)

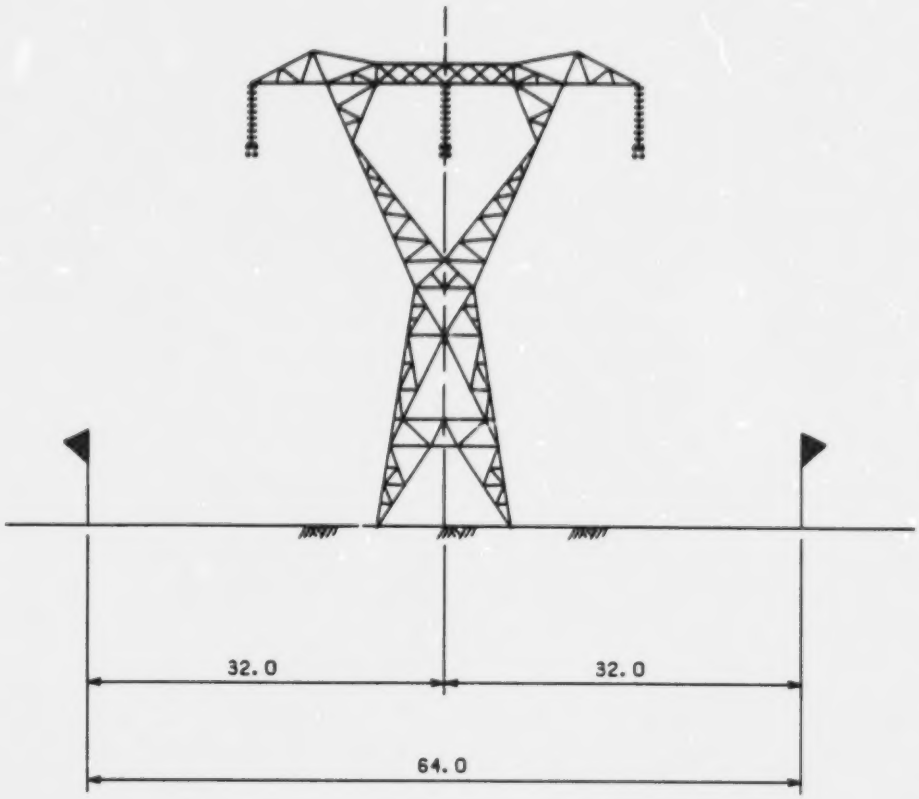
NOTES:

1. DIMENSIONS ARE PRELIMINARY ONLY. CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME I	
DATE	FIGURE 2 - 4
DWN.	DWG. No. SHEET 1 OF 4

A

PROPOSED 500 kV
SKEENA - RUPERT



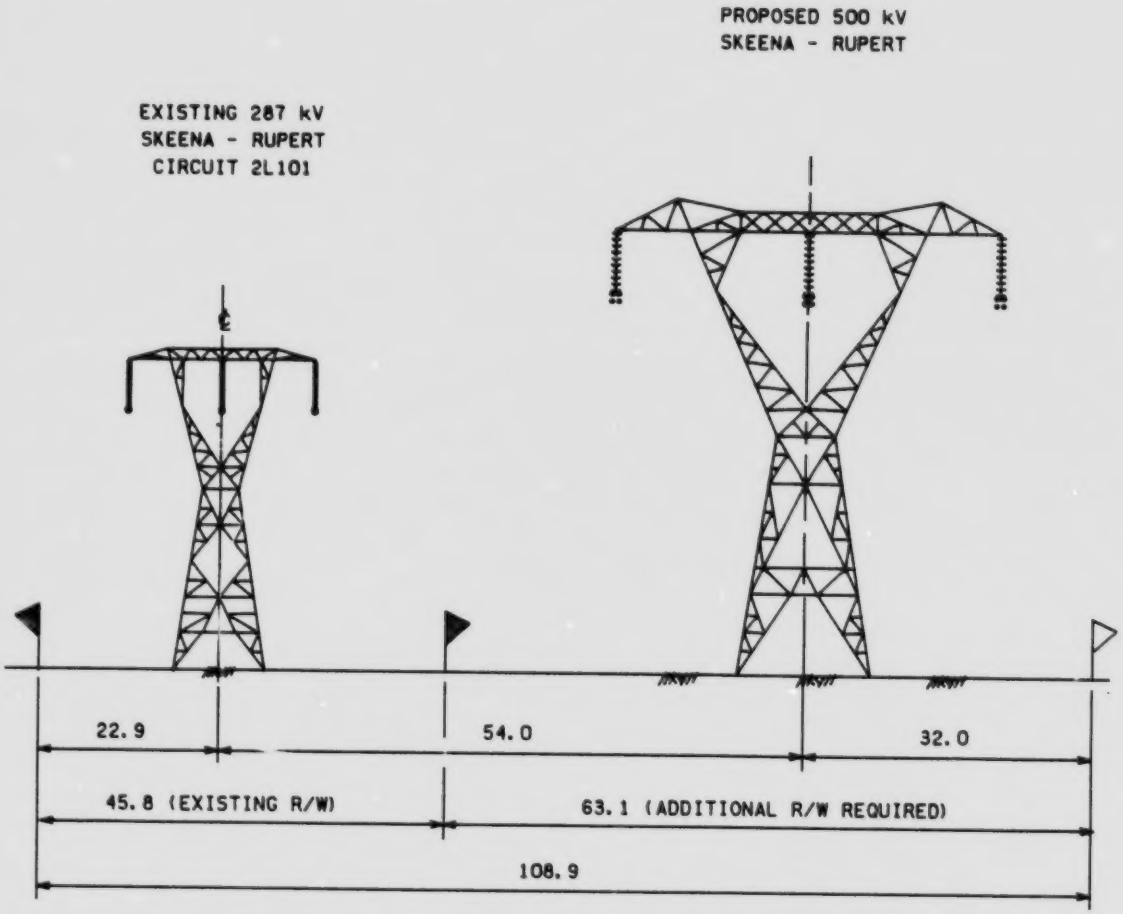
VIEW LOOKING TOWARDS RUPERT SUBSTATION
(SEGMENTS SK3, SK4, SK5, SK9 & SK13)

NOTES:

1. DIMENSIONS ARE PRELIMINARY ONLY AND MAY VARY ACCORDING TO TERRAIN.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 1	
DATE	FIGURE 2 - 4
DWN.	DWG. No. SHEET 2 OF 4

A



VIEW LOOKING TOWARDS RUPERT SUBSTATION

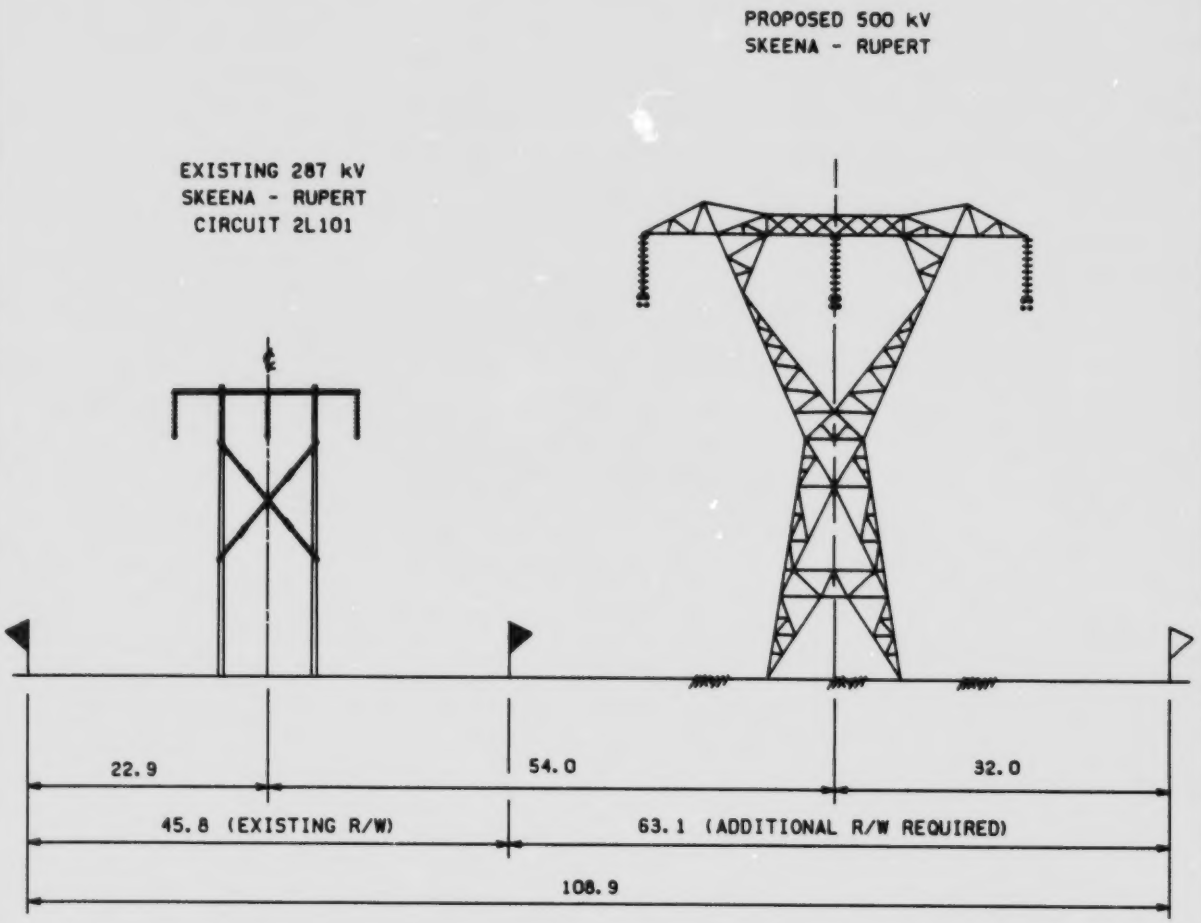
(SEGMENTS SK2, SK6, SK7, SK8, SK10 & SK11)

NOTES:

1. DIMENSIONS ARE PRELIMINARY . CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.
2. POSITION OF CIRCUITS ON RIGHT OF WAY IS REVERSED FOR SEGMENTS SK7 & SK8
3. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 1	
DATE	FIGURE 2 - 4
DWN.	DWG. No. SHEET 3 OF 4

A



VIEW LOOKING TOWARDS RUPERT SUBSTATION
(SEGMENTS SK12, & SK14)

NOTES:

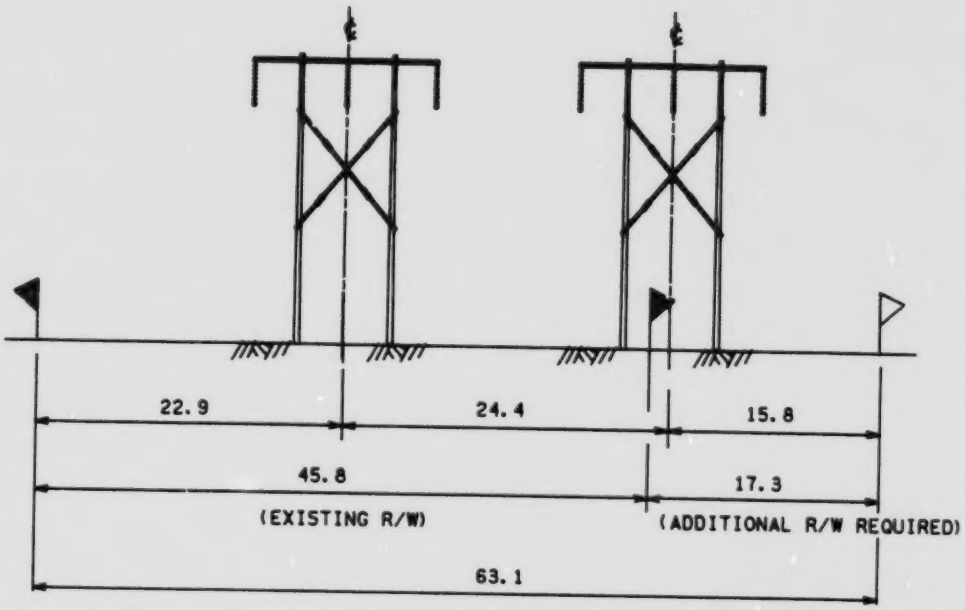
1. DIMENSIONS ARE PRELIMINARY . CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME I	
DATE	FIGURE 2 - 4
DWN.	DWG. No. SHEET 4 OF 4

A

EXISTING 287 kV
SKEENA - RUPERT
CIRCUIT 2L101

PROPOSED 287 kV
SKEENA - RUPERT OR
KITIMAT - RUPERT



VIEW LOOKING TOWARDS RUPERT SUBSTATION)
(SEGMENTS SK1 AND SK12)

NOTES:

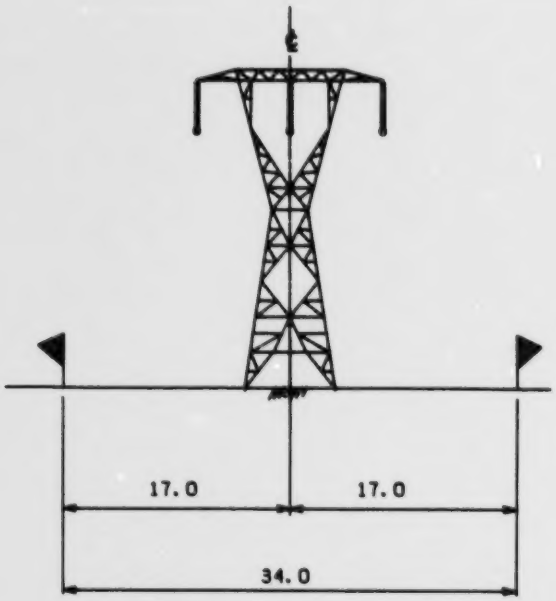
1. DIMENSIONS ARE PRELIMINARY ONLY. CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.

2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 2	
DATE	FIGURE 2 - 5
DWN.	DWG. No. SHEET 1 OF 4

A

PROPOSED 287 kV
SKEENA - RUPERT &
KITIMAT - RUPERT



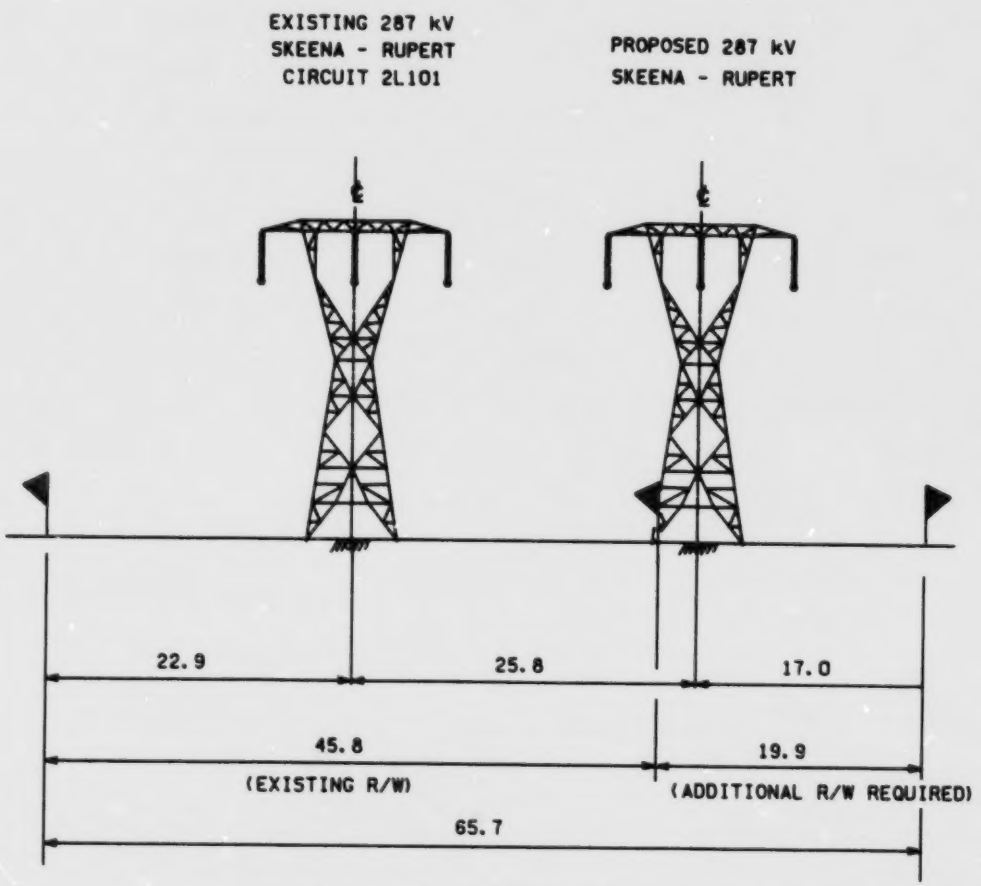
VIEW LOOKING TOWARDS RUPERT SUBSTATION)
(SEGMENTS SK3, SK4, SK5, SK9, SK13, DC1, DC2, DC3 & DC4)

NOTES:

1. DIMENSIONS ARE PRELIMINARY ONLY AND MAY VARY ACCORDING TO TERRAIN.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 2	
DATE	FIGURE 2 - 5
DWN.	DWG. No. SHEET 2 OF 4

A



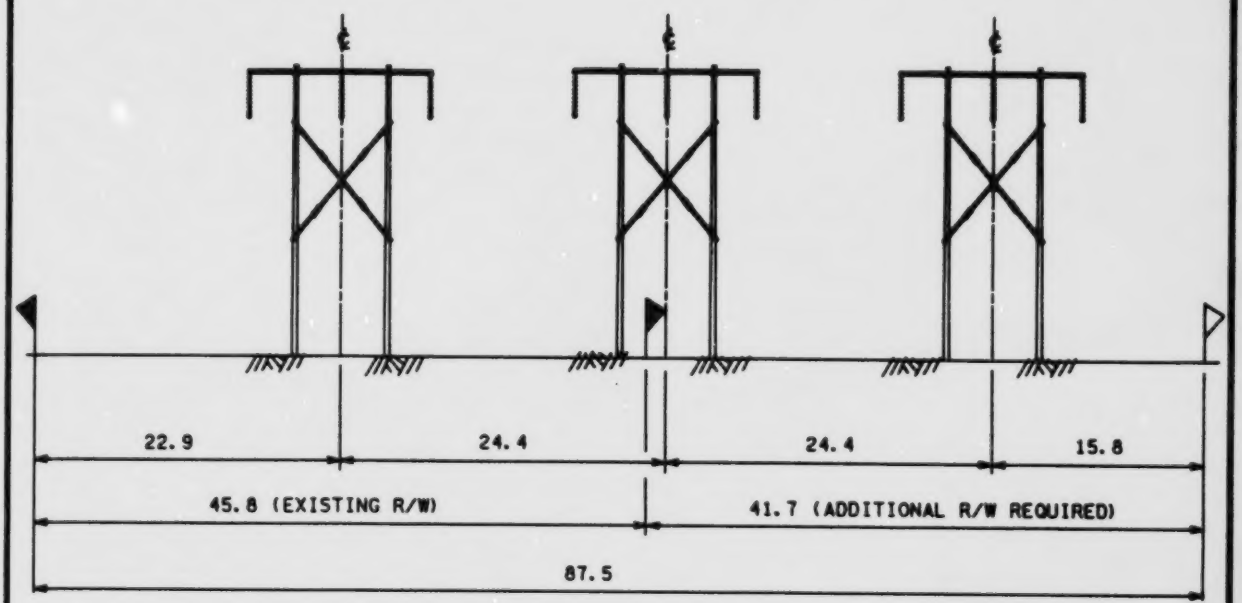
VIEW LOOKING TOWARDS RUPERT SUBSTATION)
(SEGMENTS SK2, SK6, SK7, SK8, SK10 & SK11)

NOTES:

1. DIMENSIONS ARE PRELIMINARY ONLY. CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.
2. POSITION OF CIRCUITS ON RIGHT OF WAY IS REVERSED FOR SEGMENTS SK7 & SK8
3. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 2	
DATE	FIGURE 2 - 5
DWN.	DWG. No. SHEET 3 OF 4

A



VIEW LOOKING TOWARDS RUPERT SUBSTATION

(SEGMENT SK14)

NOTES:

1. DIMENSIONS ARE PRELIMINARY ONLY. CIRCUIT SEPARATION MAY VARY ACCORDING TO TERRAIN.
2. ALL DIMENSIONS ARE IN METRES.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
SKEENA - RUPERT HIGH VOLTAGE TRANSMISSION LINE PRELIMINAY RIGHT OF WAY CROSS SECTIONS SCHEME 2	
DATE	FIGURE 2 - 5
DWN.	DWG. No. SHEET 4 OF 4

SECTION 3.0 - DELINEATION AND REFINEMENT OF ROUTE OPTIONS

3.1 GENERAL

The major engineering objective in the selection of transmission line routes is to determine the most secure route with the least cost and give due consideration to environmental factors. In order to select a preferred route which meets this engineering objective, three distinct steps are taken:

1. Possible route alternatives are delineated, then refined or eliminated based on absolute and relative design and security constraints.

2. The feasible route alternatives are evaluated and compared on the basis of technical, cost and security considerations.

3. A preferred route is selected on the basis of the evaluation.

3.2 INITIAL ROUTES OPTIONS

The first step was the delineation of possible route options which warranted field investigation. A study of various topographic maps and published geological information was undertaken to outline the obvious major constraints and modifiers within the study area.

It was evident that the delineation of possible route options would primarily be controlled by terrain. The major controlling terrain features are the prominent northwest, and somewhat less prominent northeast trending valleys. Areas above 1000 m in elevation, glaciers, icefields and exposed areas above treeline were generally treated as

absolute constraints. Large bodies of water such as Jesse, Foch, Alastair and Khtada lakes, Gilttoyees Inlet, Foch Lagoon and the mouth of the Skeena west of the Ecstall River acted as major constraints.

Cultural features such as communities and parks exercised little control over the delineation of route options because there are relatively few in the area. However, the Exchamsiks River, Prudhomme Lake and Diana-Rainbow Provincial Parks, the Floodplain Islands Ecological Reserve and most Indian Reserves would be avoided if possible.

The constraints outlined above and the linear nature of the topography served to define the possible route options outlined on Fig. 3-1. For simplicity in identification each route was given a geographical name as indicated.

Only the Skeena River and Douglas Channel routes appeared technically feasible. However it was felt that other potential routes identified warranted field investigation. For routes originating at Skeena substation these included the Mt. Campagnolo, Exstew and Kasiks routes. For routes originating at Kitimat substation, the Little Wedeene route was investigated.

3.3 UNACCEPTABLE ROUTES OPTIONS

The intent of the initial field investigations was to determine which route options were suitable for further study and which routes could be eliminated.

The following routes (Fig. 3-2) were eliminated from further study for the reasons listed below:

PHOTO 3-1 — Mt. Campagnolo Route. Pass west of Khyex River.

PHOTO 3-2 — High mountain passes between Khyex and Kasiks watersheds crossed by Mt. Campagnolo, Exstew and Kasiks Routes.

(a) Routes North of the Skeena Valley (Schemes 1 and 2)

(i) Mt. Campagnolo

This route cuts across the Exstew, Exchamsiks, Khyex and Lachmach watersheds near their headwaters. In passing from one watershed to the next, the route must follow narrow avalanche swept passes well above treeline. These passes are very exposed particularly in the headwaters of the Khyex on the eastern flank of Mt. Campagnolo.

Transmission line construction through each of the four passes would be extremely difficult due to the rugged terrain and inaccessibility. Adequate security against avalanches and ice and wind loading would be difficult, if not impossible, to attain. Extensive protection against flooding and river erosion would also be required where the route is forced to follow river flood plains particularly along the Exchamsiks and Khyex rivers.

(ii) Exstew

The Exstew route is similar to the Mt. Campagnolo route in that it crosses the same watersheds. It must, however, cross six narrow passes to do so, one of which is approximately 8 km long. Adequate security in each of these passes cannot be attained due to severe avalanche and probable extreme ice and wind loading conditions.

PHOTO 3-3 — Little Wedeene Route approaching pass near Mt. Madden from east.

PHOTO 3-4 — Little Wedeene Route descending westward from Mt. Madden along Magar Creek.

(iii) Kasiks

This route is not as inhospitable as the Exstew and Mt. Campagnolo routes because it follows the Skeena valley for a greater distance. It too, however, must traverse narrow, avalanche swept passes where an adequate degree of security cannot be attained. These passes are east of Arden and Lachmach lakes respectively. Portions of the route within the Kasiks and Khyex rivers would also conflict with a natural gas pipeline which occupies, for the most part, the most secure portion of the route. Avoidance of the pipeline and the numerous avalanche tracks in the Arden Lake pass area would be extremely difficult.

(b) Routes South of the Skeena Valley (Scheme 2 Only)

Little Wedeene

The Little Wedeene route was eliminated because of the extreme difficulties which would be encountered in crossing the pass between Mt. Madden and Mt. Carthew. The pass is flanked by two glaciers, and is highly exposed and susceptible to extreme ice and wind conditions. Also, the approaches to the pass are highly avalanche swept. Severe avalanche conditions prevail along Magar Creek, Gitnadoix River, Kadeen Creek and Khtada Lake.

An adequate degree of security cannot be obtained along this route.

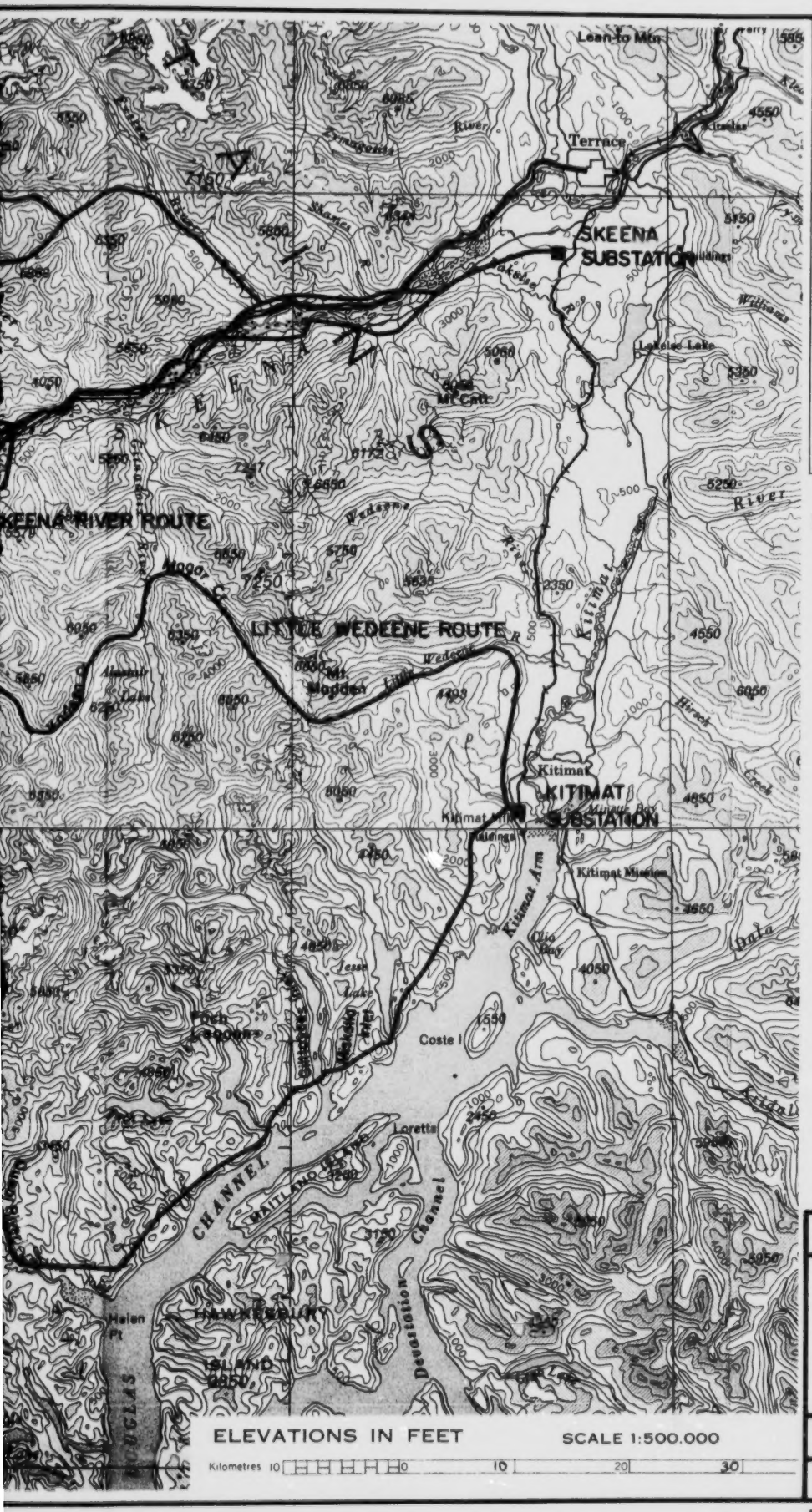
3.4 ACCEPTABLE ROUTE OPTIONS

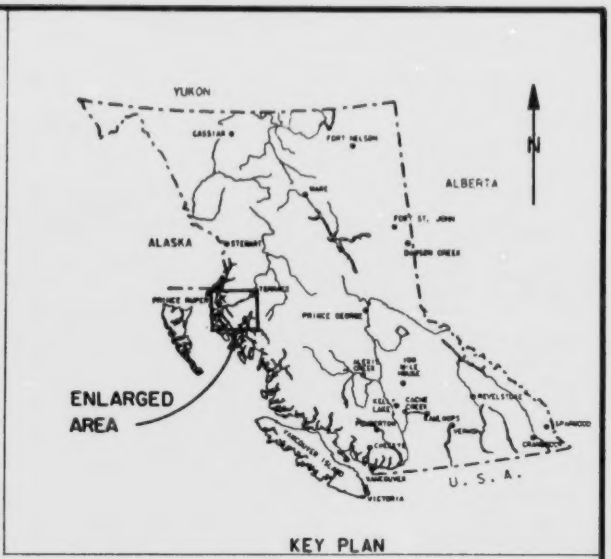
The elimination of the Mt. Campagnolo, Exstew, Kasiks and Little Wedeene routes left only the Skeena River and Douglas Channel routes for further study and evaluation. (Fig. 3-2)

Airphoto and field investigations of both routes were undertaken to identify any significant technical, security and cultural constraints within the loosely defined "boundaries" of the route. Such constraints included extensive avalanche zones, known slope failures and erosion areas, existing transmission lines, pipelines, highways and railways, etc. In some cases the routes were adjusted or alternative route segments were identified in which a specific constraint could be avoided. Four such alternative segments were identified within the Skeena valley. None were identified along the Douglas Channel route.

The acceptable routes and alternatives are described and evaluated in the following sections.

Pointer Rocks
Birnie I
Finlayson I
Port Simpson
Georgetown Mission
Big B
Trenhaile Pt
Melville Island
Tugwell Bay
Lucy Is
Digby Island
Rachael Is
Kinahan Is
Ridley I
Port Edward
Lelu I
Prescott Island
Lawyer Is
Porcher Island
Hunts Inlet
McMicking
Elliott
Kennedy
Henry
Gidas
PORCHER ISLAND
Sola Lagoon
Marrack
Kitkatla
Gurd I
Ihles
Boschen I
Dolphin I
Spicer
Ogden Channel
Gibson
Cross River
Kitkatla
Robie Mtn
McCAULEY ISLAND
PRINCE RUPERT
PRINCE RUPERT SUBSTATION
Mt McNeil
Mt Campagnolo
Mt Morse
Mt Chapleau
Smith Island
Dundas Island
Dr Horsey
Rainbow L
Haysport
Port Essington
Lakelse Lake
Lakelse River
Kitseguecla River
Kitseguecla
Kitwanga
Kitwanga River
Skeena River
CNR
Brown L
Falls River
Grenville Channel
Anger I
PRINCE OF WALES ISLAND
MT CAMPAGNOLO ROUTE
EXSTEW ROUTE
LOCHMAC-KASIKS ROUTE
SKEENA RIVER
DOUGLAS CHANNEL ROUTE
Queen Charlotte Islands
Hecate Strait
Dixon Entrance





KEY PLAN

LEGEND

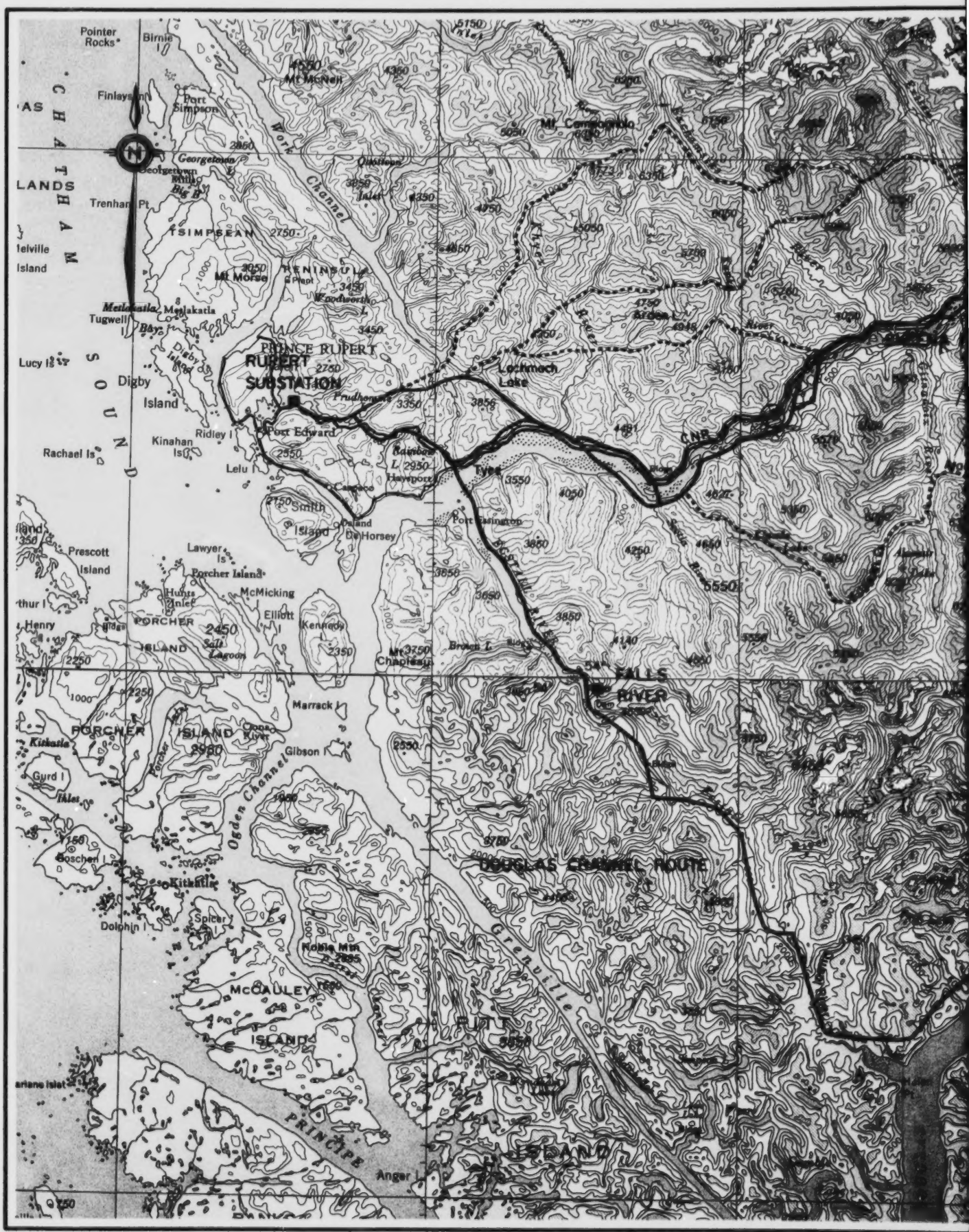
——— INITIAL ROUTE OPTIONS

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
INITIAL ROUTE OPTIONS

DATE	FIG. 3-1
DWN	DWG. No.

REPORT No


Pointer Rocks
Birnie I
Finlayson I
Port Simpson
Georgetown Mills
Big B
Trenhan Pt
TSIMPSEAN PENINSULA
Mt Morse
Melville Island
Metlakatla
Tugwell I
Boyz
Lucy Is
Digby Island
PRINCE RUPERT
RUPERT SUBSTATION
Prudhomme
Port Edward
Ridley I
Kinahan Is
Rachael Is
Lelu I
Lakelse Lake
Rainbow L
Hawkport
Tyee
CNR
Smith Island
Poland
De Horsey
Port Essington
Prescott Island
Lawyer Is
Porcher Island
Hunts Inlet
McMicking
Elliott
Kennedy
Henry
PORCHER ISLAND
Salt Lagoon
Mt Chapleau
Brown L
FALLS RIVER
Marrack I
Kitkatla
Gibson I
Gurd I
Inlet
Ogden Channel
Boschen I
Dolphin I
Spicer I
Noble Mtn
McCAULEY ISLAND
DOUGLAS CHANNEL ROUTE
Grenville
PRINCE RUPERT ISLAND
Anger I
Work Channel
Mt McNeil
Mt Campbell
Quiltieon Inlet
Woodworth L
Trudel Creek
Kasiks River
Kasiks L
Kasiks River
Kasiks Lake
Kasiks River
Kasiks River
Kasiks River

KEY PLAN

LEGEND

——— ACCEPTABLE ROUTE OPTIONS

····· UNACCEPTABLE ROUTE OPTIONS

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
REFINED ROUTE OPTIONS

DATE	FIG. 3-2
DWN	DWG. No

REPORT No

SECTION 4.0 - ROUTE DESCRIPTIONS

4.1 GENERAL

Due to the elimination of all other routes, both Schemes 1 and 2 must be adopted to the Skeena River and Douglas Channel routes. At present a 500 kV power supply is only available in the area at Skeena substation. With reference to Fig. 3-2, the most direct route between Skeena and Rupert is along the Skeena River valley. A route from Skeena substation to Rupert substation by way of Kitimat and Douglas Channel is approximately 70% longer than the Skeena Valley route. Therefore this route was not considered suitable for Scheme 1. However, with a 287 kV supply available at Kitimat, the Douglas Channel route was suitable for consideration in Scheme 2.

This section outlines a general description of the Skeena River and Douglas Channel routes. The routes are described with reference to technical and security factors but without reference to voltage or scheme.

Both routes were divided into segments at major terrain boundaries or where alternative alignments exist. [Refer to Figs. 4-1 and 4-2.] The Skeena River route was divided into 14 segments, including alternatives, and labelled SK1 to SK14. The Douglas Channel route was divided into four segments between Kitimat Substation and its intersection with the Skeena River route at the mouth of the Ecstall River and labelled DC1 to DC4.

4.2 SKEENA RIVER ROUTE (SEGMENTS SK1 TO SK14)

(a) Introduction

(i) Terrain

The Skeena River route originates at Skeena Substation, 8 km south of Terrace, and follows the Skeena Valley and either the McNeil or Lachmach and Prudhomme valleys to Rupert Substation, a distance of approximately 125 km.

West of its confluence with the Lakelse River the Skeena River flows within a broad U-shaped valley with an average width of 2.5 km. A flat, braided floodplain consisting primarily of fluvial and colluvial sites, sands, gravels and some marine clay occupies most of the valley bottom.

Between Terrace and Kwinitsa the river channel is divided into numerous channels and backwaters by regularly shifting islands and gravel bars. Islands, backwaters and swampy areas are present particularly at the mouths of the larger intersecting streams which form broad undefined deltas along the Skeena. The islands are heavily vegetated with cottonwood. They are also prone to frequent flooding.

Below Kwinitsa the main river channel broadens into a large estuary. Few islands exist beyond this point other than Carnation Island and Ayton Island. This portion of the river is subject to tidal action.

The valley walls between the Lakelse River and Tyee are very steep with slope angles varying between 25° and 35°. They are heavily treed and covered with a very thin veneer of colluvial and morainal material overlying bedrock. Vast areas of

steeply sloping bedrock are exposed where avalanching and debris slides have stripped the surface material. Precipitous bluffs rise from river level to elevations exceeding 300 m in some locations, most prominently at the mouth of the Exchamsiks River and between Kwinitsa and McLean Point.

High elevations, precipitous terrain and abundant snowfall make avalanching very common along both sides of the valley between Dasque Creek and the Khyex River. Numerous avalanche paths are visible in creek gullies and on wide open slopes.

Several creeks and rivers flow into the Skeena Valley from the north and south. Most are short, steep and originate in cirques high above the valley floor. Many show signs of frequent flooding and course change with associated high amounts of rock and forest debris. This is particularly true of Dasque and Whitebottom creeks.

(ii) Existing Facilities

Several existing facilities presently follow the Skeena River between Terrace and Prince Rupert including Highway 16, the Canadian National Railway (CNR), a 287 kV transmission line (circuit 2L101) and a gas pipeline.

Highway 16, which parallels the CNR, is constructed at the base of the slope on the north side of the river. Much of the highway has been constructed on rockfill out in the river channel. This has been done to avoid avalanche runout zones between Salvus and McLean point. Rock quarries for fill are located at short intervals along the highway. Near the mouths of the Shames, Exstew, Exchamsiks and the Khyex rivers the highway and railway have formed long straight dykes which have isolated former channels of the Skeena. These isolated areas

PHOTO 4-1 — View looking west from Skeena substation along circuit 2L101.

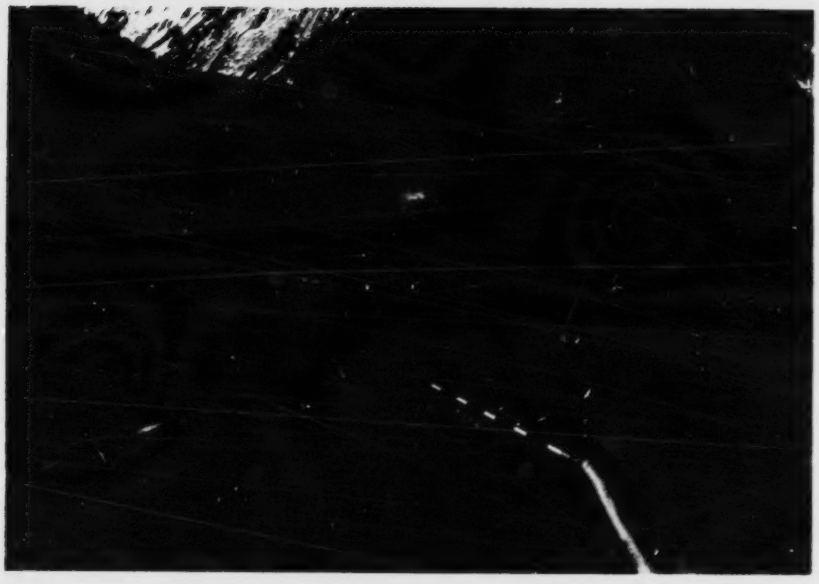


PHOTO 4-2 — View looking west along circuit 2L101 near Whitebottom Creek. Note parallel natural gas pipeline and good quality logging road.

form the only flat terrain between Terrace and Prince Rupert and are typically swampy.

The existing 287 kV transmission line occupies the south side of the river between Skeena Substation and Carnation Island. Here it crosses the river and follows Highway 16 to Rupert Substation. The line is constructed of lattice steel between Dasque Creek and Tyee, with the remainder consisting of woodpole H-frame construction. An existing 138 kV circuit (circuit 1L387) comprised of guyed aluminum tower construction parallels circuit 2L101 southwestward out of Skeena Substation for 2 km and then heads northward up the Kitsumkalum River to Kitsault and Amax Mines. Also a 69 kV woodpole line from Falls River (circuit 60L390) joins the circuit 2L101 right-of-way east of Tyee and generally parallels it to Rupert Substation.

The natural gas pipeline occupies the south side of the Skeena valley between Terrace and Salvus where it leaves the Skeena and follows the Kasiks, Khyex, Lachmach and Prudhomme valleys to Prince Rupert. This pipeline parallels and crosses under circuit 2L101 at numerous locations along its route.

One of the major criteria used in establishing the possible route alternatives was to avoid or to minimize exposure of the line to terrain hazards (Fig. 5-1) while not interfering with existing facilities. In this respect it was especially important to avoid paralleling the existing 287 kV circuit in high hazard areas wherever possible in order to minimize the possibility of losing both circuits simultaneously. For the same reason crossing of one circuit by the other was to be avoided if possible. In low hazard areas, however, paralleling the lines would be acceptable to take advantage of

PHOTO 4-3 — Circuit 2L101 near Dasque Creek. Structures protected against potential creek erosion.

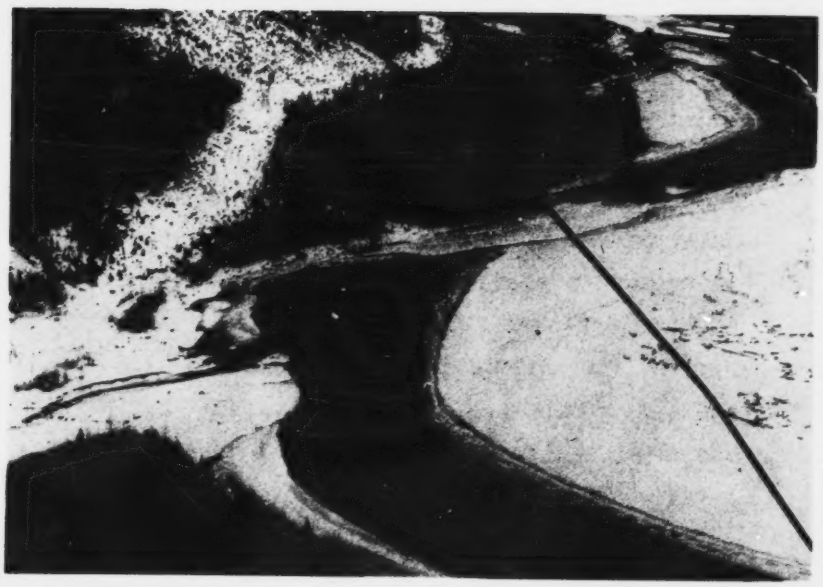


PHOTO 4-4 — Segment SK2. Route traverses point bar at right of photo to avoid serious erosion at mouth of Dasque Creek on left.

any existing access and to minimize potential environmental impact.

(b) Segment SK1

Segment SK1 parallels circuit 2L101 for 13 km and circuit 1L387 for 2 km westward out of Skeena Substation. The route is located on the north side of the existing circuits to facilitate crossing to the other side of the valley further west without crossing circuit 2L101. Circuit 1L387 is easily crossed where it leaves circuit 2L101. There are no significant design and security considerations in this segment other than erosion problems at the Lakelse River crossing. Rip-rap protection and piling was necessary for the existing line at this site. An existing high quality logging road generally following the existing line will provide good access to the route in this segment.

(c) Segment SK2

Between the Shames Indian Reserve 86 and Exstew, two route choices are available. The first, segment SK2, would continue parallel to circuit 2L101 for 4.5 km, then deviate to the north across the Whitebottom and Dasque Creek deltas to a newly-forming point bar in the main channel of the Skeena. The reason the route deviates from the existing line is to avoid serious erosion problems posed by Dasque Creek. The existing line has suffered damage at this site and extensive rip-rap protection has been provided at six structure sites. Other potential problems may also be encountered along this segment. Firstly, the main channel of the Skeena River is rapidly eroding towards the existing line. Adequate erosion protection may be difficult to construct. Secondly, a tower will be required on the point bar which, although increasing in size each year, is

PHOTO 4-5 — Segment SK2. Large avalanche paths west of Dasque Creek.

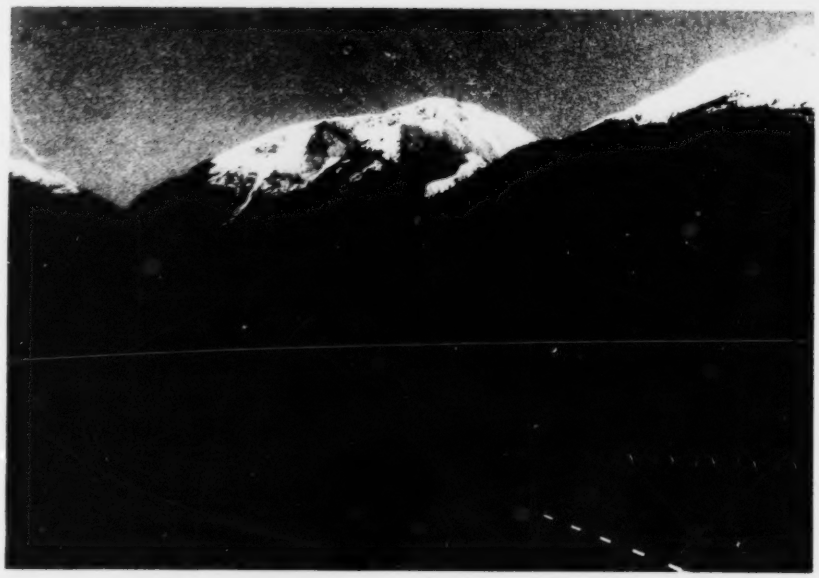


PHOTO 4-6. — Segment SK3 near mouth of Exstew River. Looking west.

still subject to severe flooding at high water as indicated by the large amount of log debris strewn across it.

Beyond Dasque Creek, segment SK2 briefly parallels the existing circuit around a bluff and then deviates across Hudson Bay Flats to the north side of the river. This deviation is necessary to avoid a high avalanche hazard on the south side of the river which is endangering the existing circuit for a distance of approximately 9 km. Avalanche berms have been constructed at 13 tower sites in this section.

(d) Segment SK3

The second, more suitable route alternative available is segment SK3. This route deviates from the existing circuit 7 km east of Dasque Creek and makes a relatively short crossing of the Skeena, Highway 16 and the CNR 5 km east of Shames. Segment SK3 then parallels Highway 16 and the CNR on the north side of the river across the flats at Shames and the mouth of the Exstew River. The line in this area can be screened from the highway if the alignment is offset sufficiently to leave a strip of trees.

The area to the east of the main channel of the Exstew is swampy and may require pile foundations. West of the main channel difficulties may be encountered in finding suitable tower sites around a high bluff above the highway and railway. However, the area can be traversed.

(e) Segment SK4

A continuation of the route on the north side of the Skeena River to Salvus, 22 km west of the Exstew, would be desirable to avoid a particularly long section of avalanche hazards and difficult

PHOTO 4-7 — Segment SK4 west of Hudson Bay Flats. View looking west.

PHOTO 4-8 — Segment SK4 at Exchamsiks Park. Looking west.

terrain on the south side of the river. However, a 7 km section of very steep terrain and extreme avalanche hazard on the north side of the river west of Exstew makes this virtually impossible. As a result, segment SK4 must traverse a series of large elongated islands at Hudson Bay Flats to the south side of the valley, briefly parallel the existing circuit and then cross back to the north side of the river past the hazardous zone. The main channel of the river is therefore crossed twice. The islands in this segment are relatively stable and few problems are foreseen in traversing them.

The route then follows the highway and railway past Exchamsiks Provincial Park to Salvus. For the most part this portion of the segment traverses low lying swampy ground adjacent to the highway - similar to that at Shames - except for a particularly difficult section around the park and bluffs at the mouth of the Exchamsiks River.

The park is located on the east side of the Exchamsiks River while the bluffs rise precipitously on the west. The highway forms the southern boundary of the park.

There are two possible alternatives for the Exchamsiks area. The first is to cross to the south side of the highway and railway east of Exchamsiks and parallel them around the base of the bluffs by utilizing outcroppings and specially constructed tower pads in the river channel. The second would be to scale the bluffs. Both are feasible but scaling the bluffs would be difficult due to limited tower sites and inaccessability. An aerial trespass of the park probably would also be required.

PHOTO 4-9 — Segment SK5 at mouth of Kasiks River. View looking north.

PHOTO 4-10 — Segment SK6 west of Exchamsiks. Looking east.

West of Exchamsiks the remainder of segment SK4 is relatively straight forward. The route would again parallel the highway and railway to Salvus across a flat, low lying area north of the highway. There is a camp facility in this area and the gas pipeline crosses the Skeena River at this point. No significant problems are foreseen in avoiding these facilities.

(f) Segment SK5

Beyond Salvus two route alternatives are available. The first, segment SK5, continues on the north side of the Skeena River to the mouth of the Kasiks River where it would then cross to the south side of the Skeena. The river crossing in this area would be difficult because several tower sites would be required on shifting islands and gravel bars prone to frequent flooding. The main river channel is not well defined in this area. Also the crossing of the CNR and Highway 16 is at a difficult point immediately east of the Kasiks River bridges.

The route does not continue on the north side of the Skeena beyond the Kasiks River because of extremely steep and avalanche prone terrain between there and McLean Point.

(g) Segment SK6

Segment SK6 offers a better crossing of the Skeena than segment SK5. Near Salvus the main channel of the river is well confined and the crossing would be short.

The route then parallels the existing transmission line on its north side for 5 km across a number of stable islands. Erosion problems may be encountered along some larger backwater channels near the mouth of Alder Creek.

PHOTO 4-11 — Segment SK7 near Feak Creek. Note large avalanche path on north side of river near Kwinitsa.

PHOTO 4-12 — Segment SK7. Route parallels existing line through high avalanche hazard area.

The river islands in the Salvus area are presently being logged and access to them and the south side of the river is provided by barges with landings at Salvus. The landings and connecting roads on the islands could possibly be utilized for construction access.

(h) Segment SK7

As stated earlier, a continuation of the route on the north side of the river is not feasible beyond the Kasiks River. As a result segment SK7 must parallel the existing line on the south side of the river through relatively hazardous terrain between Alder Creek and the existing crossing of the Skeena west of McLean Point.

Initially, segment SK7 parallels the existing line across a series of larger islands at the mouth of Alder Creek. Similiar to segment SK6, erosion and flooding problems may be encountered along some of the larger backwater channels. After crossing circuit 2L101, the route parallels the existing line on its south side except for a 2 km section adjacent to Skuttsap Indian Reserve 11 opposite Kwinitsa. In this section the route takes a more direct alignment across higher ground. This route is shorter than following the existing line around the base of the hill along the Skeena River and results in fewer heavy angle structures.

The most significant problem with segment SK7 is the need to parallel the existing line through a high avalanche danger zone, particularly between the Skuttsap Indian Reserve and the existing Skeena River crossing. Because of the necessity to stay on the south side of the existing line due to the closeness of the Skeena River on the north, the proposed line would be located on a steep slope within the runout zone of several avalanche paths. Judicious placement of structures and avalanche protection will be required at several locations. Additional protection along the existing line may also be required due to the removal of forest cover above.

PHOTO 4-13 Segment SK8 parallel to circuit 2L101 at Carnation Island. Note rock quarry.

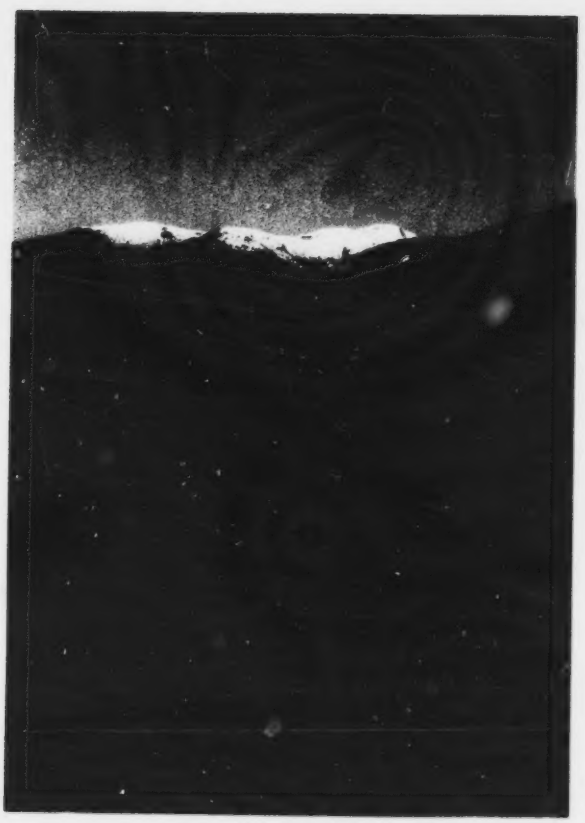


PHOTO 4-14 — Segment SK8 parallel to circuit 2L101. View looking west.

Access to most of segment SK7 will probably be limited to the use of barges and helicopters due to steep, rocky terrain.

(i) Segment SK8

Steep, inaccessible terrain west of Ayton Creek precludes a continuation of the route on the south side of the Skeena River beyond that point. Because of the extreme width of the main channel between the mouth of the Scotia River and Ayton Creek, only two reasonably good river crossings are available. These are at Carnation Island parallel to the existing line and at Ayton Island 6 km downstream.

The Carnation Island crossing (the shorter of the two at 2 km) would be very similar to the existing crossing with two special towers constructed in the river channel. The river is shallow at this point, therefore construction of the special pile footings should not be exceedingly difficult.

Segment SK8, utilizing the Carnation Island crossing, parallels the existing line on it's southern side well above the highway and railway between the crossing and a point 2.5 km east of the mouth of the Khyex River where it would cross the existing line. This section has a very steep rocky sideslope and is heavily treed. There is no road access along the existing line and hand clearing has been necessary. The situation would be similar for the proposed line.

A potentially serious avalanche hazard exists along most of segment SK8. There is a large, open slope above the route which is subject to frequent avalanching, the lower limit of which is located not far above the proposed route. Large, unconfined avalanches could reach the existing and proposed lines during a

PHOTO 4-15 — Segment SK9 between Carnation Island and Snag Point in right background. Note avalanche paths.

PHOTO 4-16 — Segment SK10 looking west. Route crosses the Khyex river and Indian Reserve parallel to the existing line. Logged area is at entrance to the Antigonish/Lachmach valley.

heavy snowfall year. A few confined avalanches have crossed the existing line. However, a sequence of small ridges above and parallel to the route are serving to reduce the avalanche hazard by slowing and deflecting the movement of snow. Some avalanche protection may be necessary.

(j) Segment SK9

Segment SK9 leaves circuit 2L101 at the existing Skeena crossing, crosses the mouth of the Scotia River and traverses a steep slope to Snag Point where it crosses the Skeena via Ayton Island. The Ayton Island crossing is more oblique than the Carnation Island crossing and is more than twice as long. This is due to the elongation of Ayton Island and its associated gravel bars downstream of Snag Point. Poor foundation conditions, an Indian reserve and a large logging camp and booming grounds are encountered at the mouth of the Scotia River. The slope between the Scotia River and Snag Point is very steep, inaccessible and avalanche prone.

(k) Segment SK10

The only significant feature of segment SK10 which stretches between the mouths of the Khyex River and Antigonish Creek is the Khyex Indian Reserve 8 at the mouth of the Khyex River. If the Indian reserve can be traversed, the route will be relatively straight forward, being parallel to the existing line on flat accessible terrain. If the reserve cannot be traversed a route around the north side of the reserve would have to be taken. This would involve a series of heavy angle structures, the traversing of relatively steep terrain and the avoidance of the Pacific Northern Gas pipeline on the west side of the Khyex River.

PHOTO 4-17 — Segment SK11 west of Khyex River.

PHOTO 4-18 — Segment SK12 parallel to circuit 2L101 and 60L390 west of Tyee.

(l) Segment SK11

There are two major route alternatives between the mouth of Antigonish Creek and the west end of Prudhomme Lake. These include a route parallel to the existing line which generally follows Highway 16 past Tyee and Rainbow Lake to Prudhomme Lake. The second alternative follows Antigonish Creek and the Lachmach River to the head of Work Channel, over a pass north of Minerva Lake and along the northwest side of the Prudhomme drainage system.

The route which follows the existing line, segment SK11, would be located on the north side of the existing line between Antigonish Creek and Tyee. This section is steep, rocky and generally inaccessible.

There are a few avalanche paths along segment SK11. However, because of a warmer, wetter coastal influence and different terrain the avalanche danger subsides and debris slides become more prevalent. This area is also prone to heavy icing conditions due to a mixing of warm coastal air with cooler air flowing down the valley from the north. Ice damage has occurred to both the existing 287 kV and 69 kV lines in this area.

(m) Segment SK12

In segment SK12, northwest of Tyee, the terrain takes on a different character than that of the Skeena Valley. The area consists of low, rolling mountains heavily scoured by glaciation. Rock outcrops are prevalent as are numerous depressions filled with clay and deep deposits of organic matter. Some of the steeper slopes are covered with a very thin veneer of glacial and organic material which is particularly susceptible to debris flows. Some debris flows have originated in the heavily timbered areas while most are prevalent in logged off areas.

PHOTO 4-19 — Segment SK13 looking east from pass between Antigonish Creek and Lachman River.

PHOTO 4-20 Segment SK13 looking northeast from Prudhomme Lake to pass west of Minerva Lake.

Between Tyee and Prudhomme Lake, the existing line, which is of wood pole construction west of Tyee, shares the right-of-way with the Falls River 69 kV transmission line. Both cross Highway 16 four times in this section. To minimize interference with the highway, the proposed route parallels the existing 287 kV line on the north. A 2 km section of the 69 kV line between Rainbow and Prudhomme lakes may need to be relocated to the south side of circuit 2L101 in order to locate the proposed line between the existing 287 kV circuit and the highway.

Segment SK12 continues across Prudhomme Lake parallel to the existing line to Taylor Lake.

(n) Segment SK13

The Lachmach/Prudhomme alternative, segment SK13, traverses generally similar terrain as segments SK11 and SK12, but it is more isolated.

The Lachmach River valley is a narrow U-shaped valley with steep side slopes prone to avalanching and debris slides. The west side of the valley has recently been logged while the east side is occupied by the natural gas pipeline. The valley bottom is narrow and is occupied by the river and small lakes in the pass. Because of the debris slide activity on both sides of the valley, the least hazardous route is in the extreme valley bottom along the river.

In passing from the Lachmach River into the Prudhomme Lake drainage system, the route takes a narrow pass along the northern edge of Minerva Lake. The area is relatively steep and may be prone to debris slide activity. A narrow pass at the head of the Prudhomme Lake drainage system west of Minerva Lake with similar conditions must also be traversed.

PHOTO 4-21 — Segment SK14 looking west to Rupert Substation. Gas turbine plant in right foreground.

PHOTO 4-22 — Same as above.

The remainder of the route along the northwestern flank of the Prudhomme valley is not well defined due to the highly undulating terrain. The valley is very wet with numerous deposits of clay and organic matter. Pile foundations will probably be necessary in crossing these depressions. Access road construction in this material would also be difficult as evidenced by the large sections of temporary cordouroy road built along the pipeline route. Most of this access has been destroyed by erosion and would be virtually unusable for transmission line construction.

(o) Segment SK14

Segment SK14 follows the north side of the existing line and Highway 16 from Prudhomme Lake to Rupert Substation. The only troublesome portion of this segment would be the entrance to the east side of the substation which is partially blocked by the gas turbine plant and maintenance building. If sufficient clearance to these buildings cannot be attained, relocating circuit 2L101 towards the highway would be necessary.

4.3 DOUGLAS CHANNEL ROUTE (SEGMENTS DC1 TO DC4, SK12 AND SK14)

(a) Introduction

(i) Terrain

The Douglas Channel route originates at Kitimat Substation adjacent to the Alcan aluminum smelter 7 km southwest of Kitimat. It follows the west side of Douglas Channel and the Quaal and Ecstall rivers to the mouth of the Skeena River, then along Highway 16 to Rupert Substation, a distance of approximately 162 km.

PHOTO 4-23 — General view of Douglas Channel looking north to Kitimat.

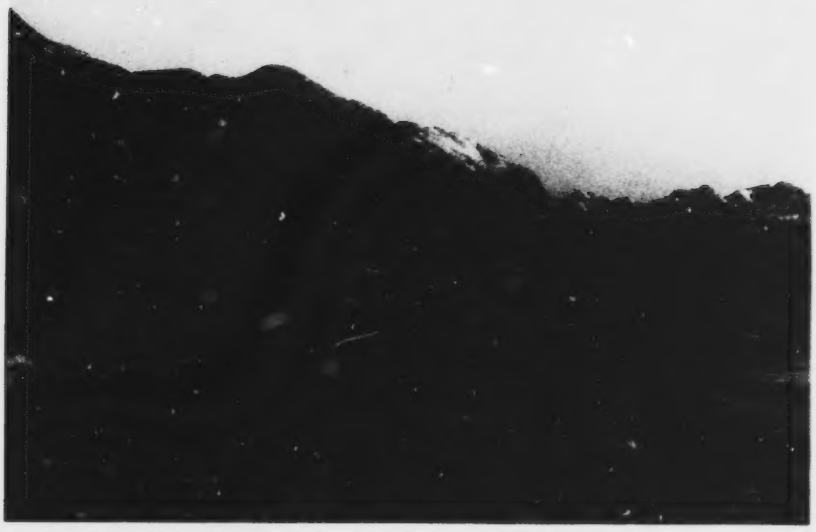


PHOTO 4-24 — General view of Ecstall River looking southeast. Note Falls River 69 kV right-of-way in lower left.

The west side of Douglas Channel between Kitimat and Kitkiata Inlet is typical of B.C. coastal inlets with slopes rising steeply from sea level to elevations exceeding 1000 m. Slope angles vary between 25° and 35°.

The shoreline is generally rocky with few beaches - typical of "drowned" glacial topography. There are numerous smaller inlets or pseudo-inlets which intersect Douglas Channel from the northwest including Jesse Lake, Miskatla Inlet, Gilttoyees Inlet and Foch Lagoon. These inlets are also extremely steep and rocky.

Rock outcrops are prevalent. The remainder of the area has a relatively thin veneer of glacial or colluvial material over bedrock. The slopes are densely forested with mature fir, cedar and hemlock, however, virtually no logging has been undertaken probably due to the extremely rugged terrain and the inaccessibility of the area.

The Quaal River which flows into Kitkiata Inlet and Douglas Channel 55 km southwest of Kitimat, and the upper reaches of the Ecstall River between Ecstall and Johnston lakes are typical U-shaped glacial valleys. The valley bottoms are broad and flat and the walls are steep. Both rivers tend to meander from valley wall to valley wall forming broad flood plains with large expanses of low lying swampy ground and meadows.

Glacial materials such as sand, silts and gravels are prevalent particularly where intersecting streams form large alluvial fans. However, the large marshy areas are probably underlain by glacial silts and clays as well as deep organic deposits.

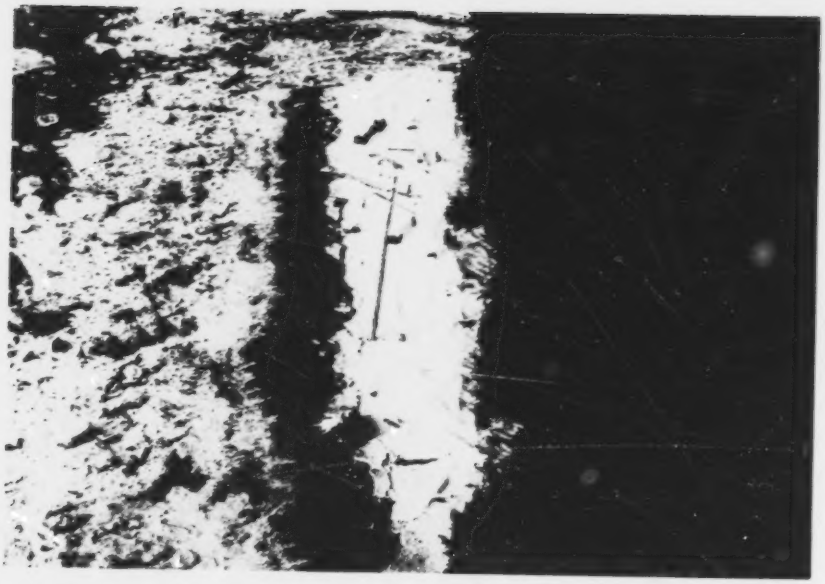


PHOTO 4-25 — Circuit 60L390 from Falls River.

PHOTO 4-26 — Kitimat Substation.

Both valleys are densely forested, however, no logging has been undertaken.

Downstream of Johnston Lake to Falls River, the Ecstall valley is narrow, sinuous and avalanche swept. The valley walls in this section are extremely steep with numerous bluffs rising precipitously out of the river.

Between Falls River and Port Essington the Ecstall River forms an estuary which stretches for approximately 25 km. The valley walls are very steep, particularly on the west side. The average width of the Ecstall river in this section is 1 km.

There are numerous creeks and rivers which flow into the Ecstall. Most originate in hanging valleys and cascade down into the main valley in a series of falls such as Falls River and the creek eminating from Brown Lake.

(ii) Existing Facilities

The only existing facility along the Douglas Channel/Ecstall corridor between Kitimat and Port Essington is a 69 kV transmission line along the east side of the Ecstall River valley from Falls River to the Skeena River. This line is of single pole wishbone construction and skirts the base of the slope immediately above river level. After reaching the Skeena River it swings east up the Skeena and crosses to the north side of the valley at Hotspring Point. It then follows Highway 16 to Rupert Substation. The Skeena River crossing is made on tall, lattice steel structures.

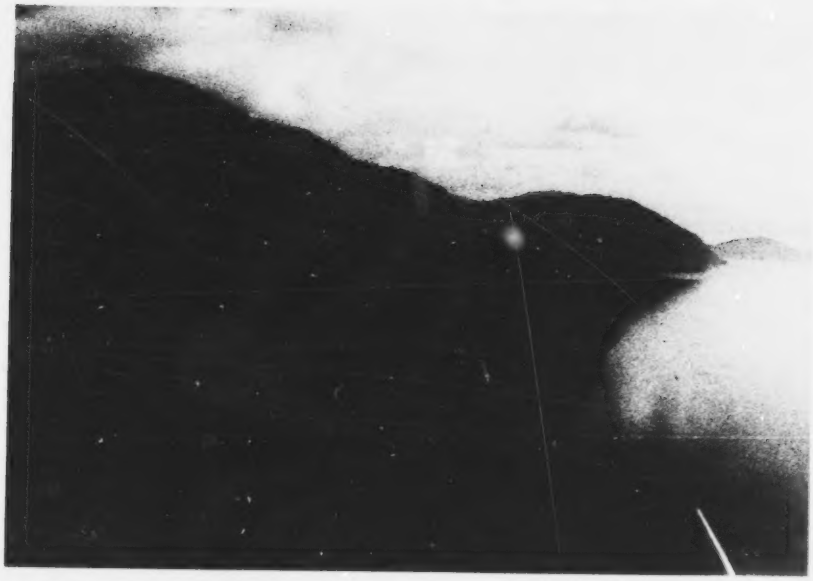


PHOTO 4-27 — View looking north along Douglas Channel. Note steep, rocky shoreline making water access difficult.

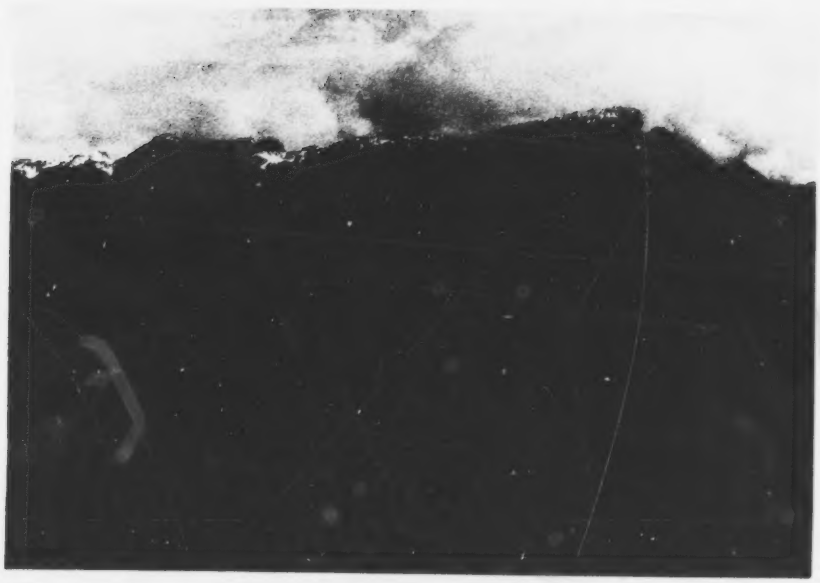


PHOTO 4-28 — Segment DC2 fat Gilttoyees Inlet. This inlet is typical of others along Douglas Channel.

As stated previously, the Douglas Channel route is very isolated. There are no roads into the area. The Falls River Generating Station and 69 kV transmission line are serviced by barge and helicopter.

Between Tyee and Rupert Substation, the Douglas Channel route is common to segments SK12 and SK14 of the Skeena River route.

(b) Segment DC1

The route heads west out of Kitimat Substation and climbs the north flank of Moore Creek to its headwaters. The maximum elevation is 760 m. It then drops down into Bish Creek 3 km from its mouth. The route then follows a low pass into Emsley Creek, up a steep bluff and along a high ridge to Jesse Falls at the south end of Jesse Lake. Due to the width of Jesse Lake a crossing somewhere in the vicinity of Jesse Falls is necessary.

The terrain in this segment is typically rough, mountain topography. Steep rocky slopes are prevalent and the remainder of the area is covered by a thin veneer of glacial material over bedrock.

Access road construction would be difficult and would probably be limited to spur roads from the mouth of Bish Creek and Emsley Cove where barge landings could be constructed. The remainder would probably require helicopter construction, particularly along a rough section between Emsley Cove and Jesse Falls.

Segment DC1 is heavily forested with good timber. However, there is no logging at present in the area.

PHOTO 4-29 — Segment DC2 at entrance to Foch Lagoon. Route traverses hanging valley at center of photo.

PHOTO 4-30 — Segment DC2. Exposed area above Gertrude point.

The main hazards along the route in this segment are debris flows on some of the steeper slopes and high wind and possible ice loading where the route is exposed to Douglas Channel between Emsley Cove and Jesse Falls.

(c) Segment DC2

Extremely rugged terrain is encountered along segment DC2 between Jesse Lake and Kitkiata Inlet.

The route climbs a steep slope out of Jesse Falls, traverses a high knoll north of Hilton point and drops down to the eastern shore of Miskatla Inlet at a narrow spot 5 km up the inlet from Douglas Channel. A 1 km long span would be necessary to cross Miskatla inlet to a long narrow peninsula between Miskatla and Gilttoyees Inlets. The route then traverses down the peninsula to its tip and crosses Gilttoyees Inlet at its southern end. An 800 m span would be required to cross this inlet.

From a small knoll on the west side of Gilttoyees Inlet the route takes a narrow pass through to Power Creek and goes over another ridge down to a narrow passage between Foch Lagoon and Drumlummon Bay. A long span is required to cross Foch Lagoon.

The long crossings of each of the inlets will be exposed to high transverse winds flowing up from Douglas Channel or down from the high glacier capped peaks to the north. Crossings further inland are generally not desireable due to their extreme widths which would require specialized conductors and structures.

From Foch Lagoon the route traverses the northwestern flank of Douglas Channel to Kitkiata Inlet. This portion of the route is very steep and rugged. This is particularly true of the section north of Gertrude Point where the route must traverse a narrow

PHOTO 4-31 — Segment DC3 looking southeast towards Ecstall Lake. Swampy conditions are typical of the segment between Kitkiata Inlet and Johnston Lake.

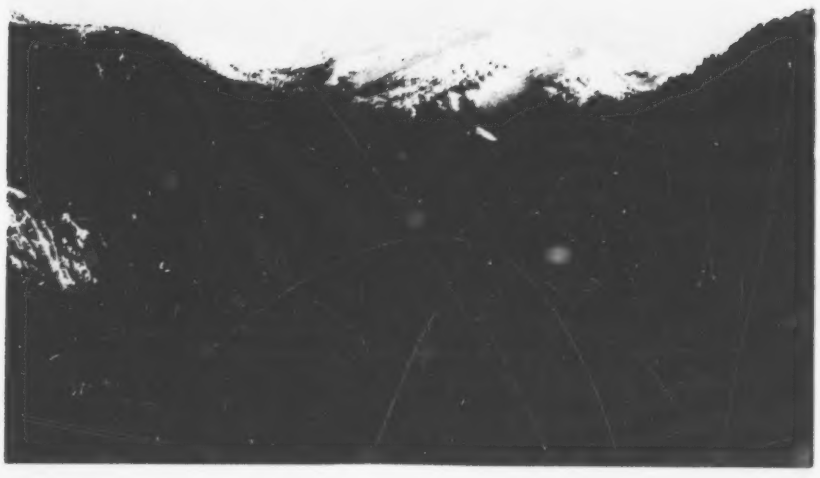


PHOTO 4-32 — Segment DC3 near Sparkling Creek. This portion of the route is narrow, sinuous and avalance swept.

ridge across a 35°, avalanche swept slope. This area is also transversely exposed to high winds coming directly up Douglas Channel from the south, as evidenced by wind shaped trees and barren alpine areas at an elevation less than 600 m.

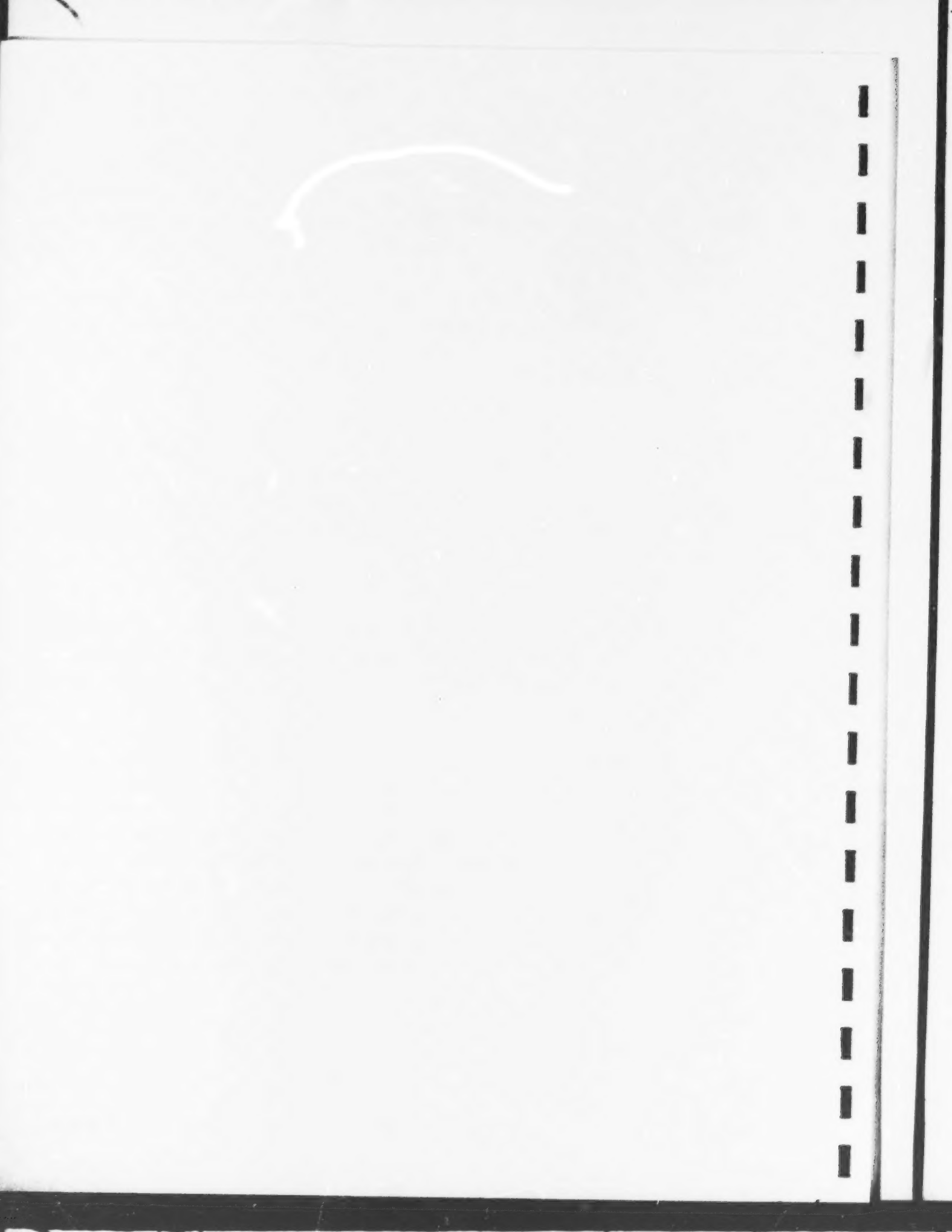
The remainder of the segment traverses steep, heavily forested terrain similar to segment DC1. Debris slides are prevalent due to the high rainfall and the thin mantle of glacial material blanketing the steep bedrock areas.

Access road construction along most of segment DC2 would be very difficult. Helicopter or other construction techniques would be required. There also is a lack of flat ground along Douglas Channel near the route where barge landings and material yards would be required.

(d) Segment DC3

The majority of segment DC3 between Kitkiata Inlet and the confluence of the Ecstall River and Sparkling Creek traverses relatively flat terrain except for steep areas past Ecstall Lake and the portion west of Johnston Lake.

Between the head of Kitkiata Inlet and Ecstall Lake the route follows the east side of the Quaal River valley. The route, at the toe of the slope, is a compromise to avoid numerous meanders and marshy areas along the river and the steeper side slope which is quite prone to debris flow activity. However, the marshy areas cannot be entirely avoided particularly at the north end of the Quaal valley just prior to entering the pass into the Ecstall valley. In this area swampy meadows up to 1 km long are encountered. Pile foundations would probably be necessary.



The pass between the Quaal and Ecstall rivers is occupied by a long narrow lake with very steep walls. The best route past the lake is around the east side, however, this area is very steep and construction would be difficult. The slope is also prone to some avalanching and could be prone to debris flow activity.

Beyond Ecstall Lake the route follows low lying swampy ground again along the west side of the Ecstall River. Large marshes similar to the Quaal are encountered. Pile foundations would probably be necessary. The valley bottom affords a better route than along the valley walls which are very steep, particularly on the east side. The route on the west side, however, must cross a series of alluvial fans which may pose an erosion hazard.

The remainder of segment DC3 between Johnston and Sparkling creeks is perhaps the most difficult and hazardous portion of the entire route. The Ecstall River passes through a narrow winding canyon with steep walls. Numerous gullies, aligned north and south and transverse to the valley, form large avalanche paths. There is evidence that large avalanches regularly flow completely across the river to the opposite side of the valley. The only reasonable route through the area is generally on the north side of the river where some advantage can be taken of ridges for tower placement. However, a secure route would be difficult to attain.

An Indian reserve at the mouth of Johnston Creek may also restrict the route.

Due to the isolation of the area a continuous access road would probably be built for construction and maintenance along segment DC3 between Kitkiata Inlet and the main channel of the Ecstall River. Such an access road would be very difficult to construct and maintain primarily due to the swampy conditions.

PHOTO 4-33 — Segment DC4 southeast of Falls River. Route traverses gravel bar on right to avoid avalanche paths.

PHOTO 4-34 — Segment DC4 southeast of Falls River. Note swampy area on left.

Also because of the meandering nature of the rivers, numerous bridges would be required.

(e) Segment DC4

Segment DC4 stretches along the east side of the Ecstall River from Sparkling Creek to Tyee on the Skeena River. This segment is the longest at 44 km and traverses rugged terrain for the most part.

At the southern end the route swings back and forth across the Ecstall River to avoid large avalanche paths which are prevalent on the slopes near the outside bends of the river. Advantage is thus taken of the flat bars which have formed on the inside of the river bends to keep the route away from the avalanche swept slopes. These bars, however, tend to be swampy and may require pile foundations.

At Falls River segment DC4 joins the 69 kV right-of-way which winds its way along the eastern shore of the Ecstall River. The shoreline is very rocky with slopes averaging 35°. There are several steep bluffs along the route. Rockfalls and avalanches are prevalent, particularly between Falls River and Hayward Creek. The only flat areas are at the mouths of Hayward and Cuthbert creeks and these areas tend to be swampy.

Northwest of Falls River some of the slopes are forested with large stands of timber and some logging is taking place, mainly up the Hayward Creek valley. Access to these logging shows is by barge as road construction in the area is virtually impossible.

The route in this segment is only feasible if extensive portions of the 69 kV line can be relocated to accommodate the proposed line. Good structure sites are very limited and most are now occupied by the 69 kV structures. In general, the proposed line would be

PHOTO 4-35 — Segment DC4 northwest of Falls river. Route follows 69 kV line at base of bluffs.

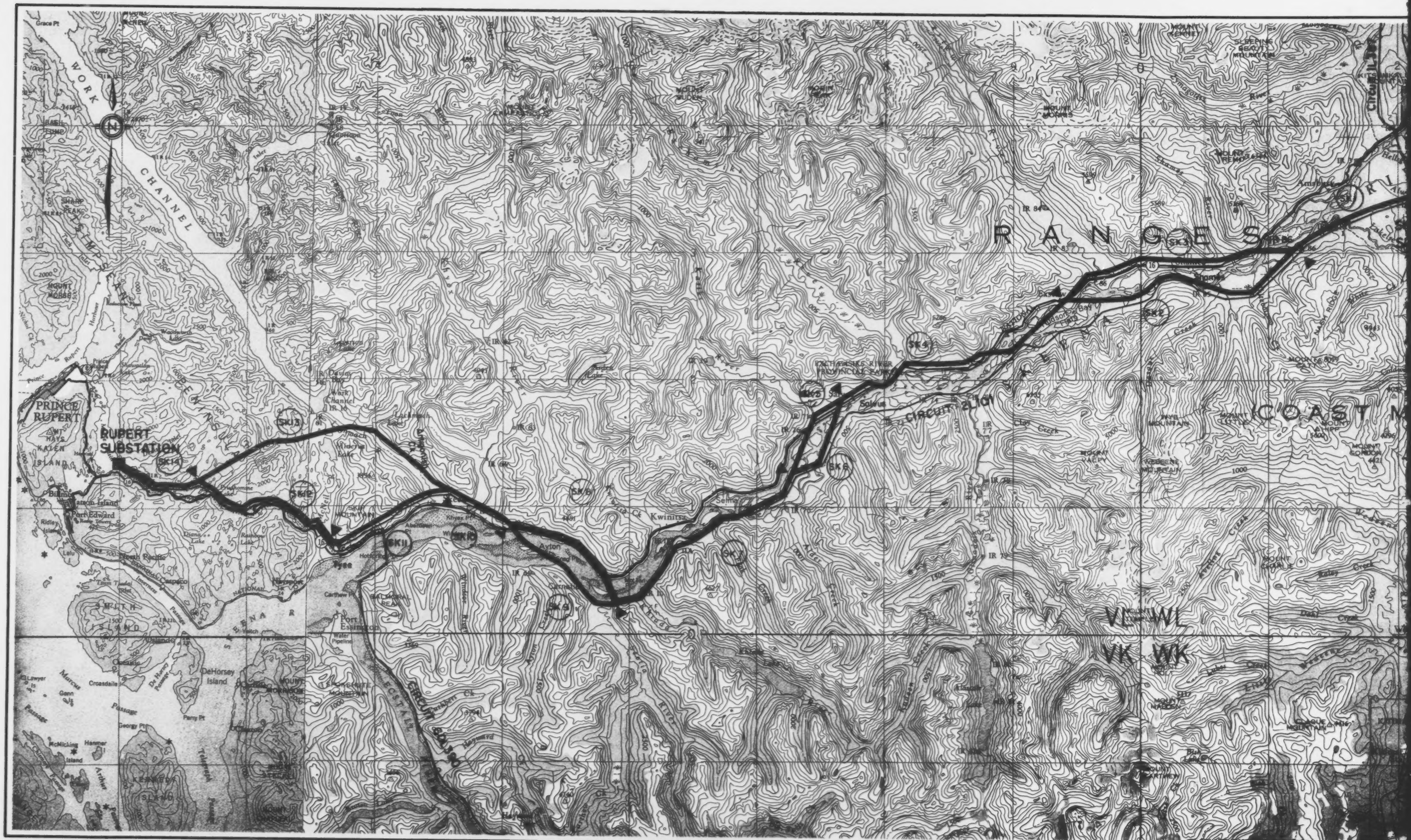
PHOTO 4-36 — Segment DC4. View looking west. Crossing of Skeena River and Raspberry Islands in left background. Circuit 60L390 river crossing in foreground. Note circuit 2L101 on right of photo.

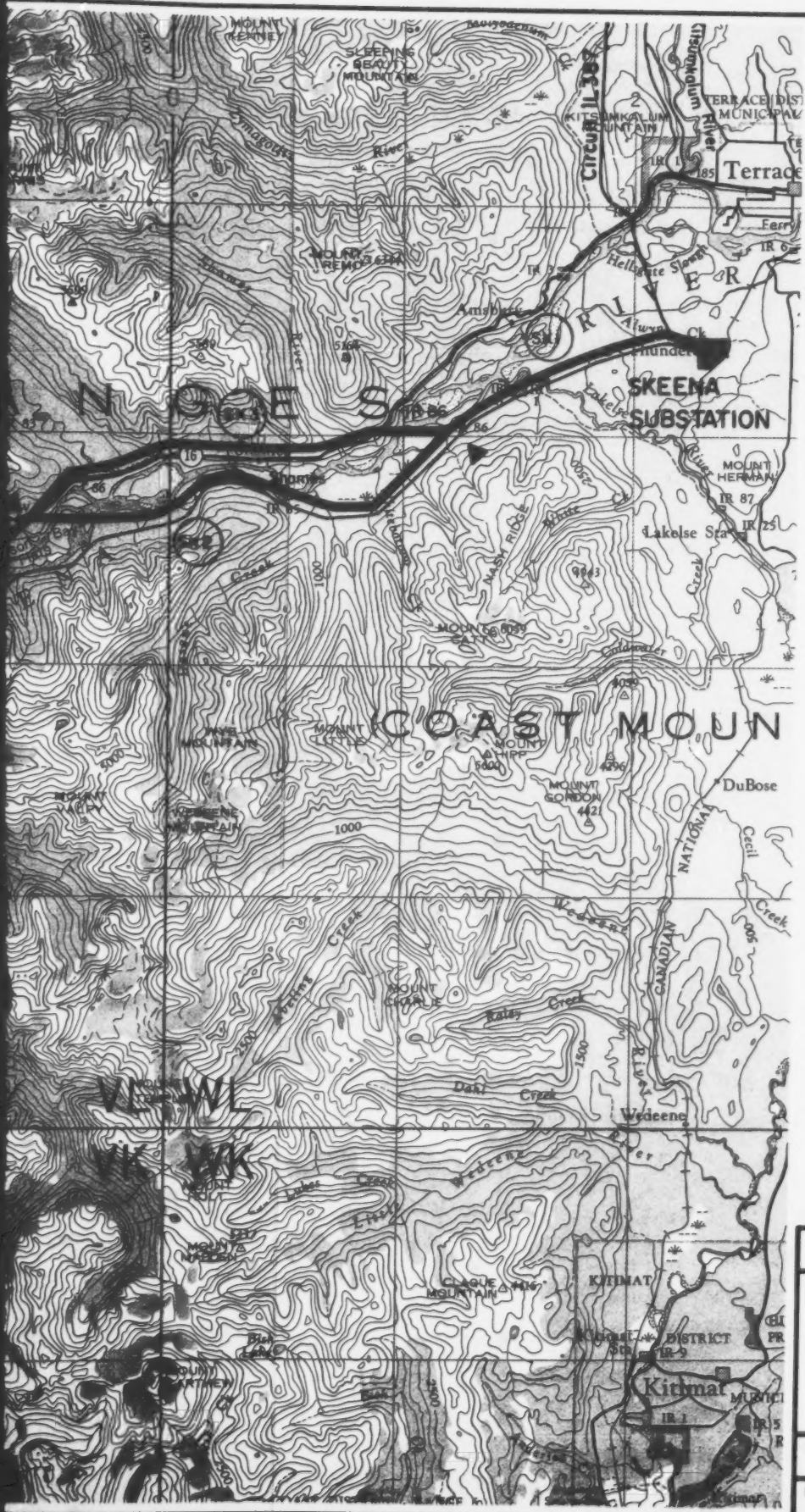
located above the 69 kV line. This may also make construction difficult. It is anticipated that helicopter construction techniques with material supplied by barge or similar means would be utilized over most of this segment.

Segment DC4 leaves the 69 kV line at Carthew Point, then crosses the Raspberry Islands and the Skeena River to Tyee. This river crossing is approximately 3 km long and would require tall structures on large pile footings. There are no obvious gravel bars in the river channel at this location possibly indicating that the river is relatively deep. This may render the crossing infeasible. In such a case the route would have to follow the 69 kV line eastward and cross at Hotspring Point. This would add approximately 10 km to the route.

(f) Segments SK12 and SK14

Between Tyee and Rupert Substation the Douglas Channel route is common to segments SK12 and SK14 which have been described previously.


PRINCE RUPERT
RUPERT SUBSTATION
SK14
SK13
SK12
SK11
SK10
SK9
SK8
SK7
SK6
SK5
SK4
SK3
SK2
SK1
CIRCUIT 2-104
CIRCUIT 2-101
CIRCUIT 2-102
CIRCUIT 2-103
CHANNEL
WORK
PORT EDWARD
Prince Rupert
Kaien Island
Digby Island
Port Essington
Dyse
Kwinitsa
Skeena River
Skeena Mts
Coast Mts
Mount Hubbard
Mount Wedge
Mount Gordon
Mount Hickman
Mount Hankin
Mount Little
Mount Hyndman
Mount Mcnaren
Mount Mcnaughton
Mount Mcnicoll
Mount Mcnulty
Mount Mcpherson
Mount Mcrae
Mount Mcrobb
Mount Mcvittie
Mount Mcwilliams
Mount Melville
Mount Menzies
Mount Mercer
Mount Meredith
Mount Mickinson
Mount Middleton
Mount Mignon
Mount Mills
Mount Mitchell
Mount Moore
Mount Morgan
Mount Morrison
Mount Mortimer
Mount Mosley
Mount Mowat
Mount Mulligan
Mount Munday
Mount Murchison
Mount Murray
Mount Mussallem
Mount Myers
Mount Nelson
Mount Nesbitt
Mount Newcombe
Mount Nicholson
Mount Nicholson
Mount Nisbet
Mount Nolan
Mount Norgate
Mount Norman
Mount Norris
Mount Northcote
Mount Northwood
Mount Norton
Mount Nowell
Mount Nugent
Mount Nunn
Mount Nuttall
Mount Nyce
Mount Oakley
Mount Oakley
Mount Oakley



KEY PLAN

LEGEND

EXISTING CIRCUITS

ROUTE SEGMENTS

Scale 1 : 250,000

Kilometres 5 0 5 10

ELEVATIONS IN FEET

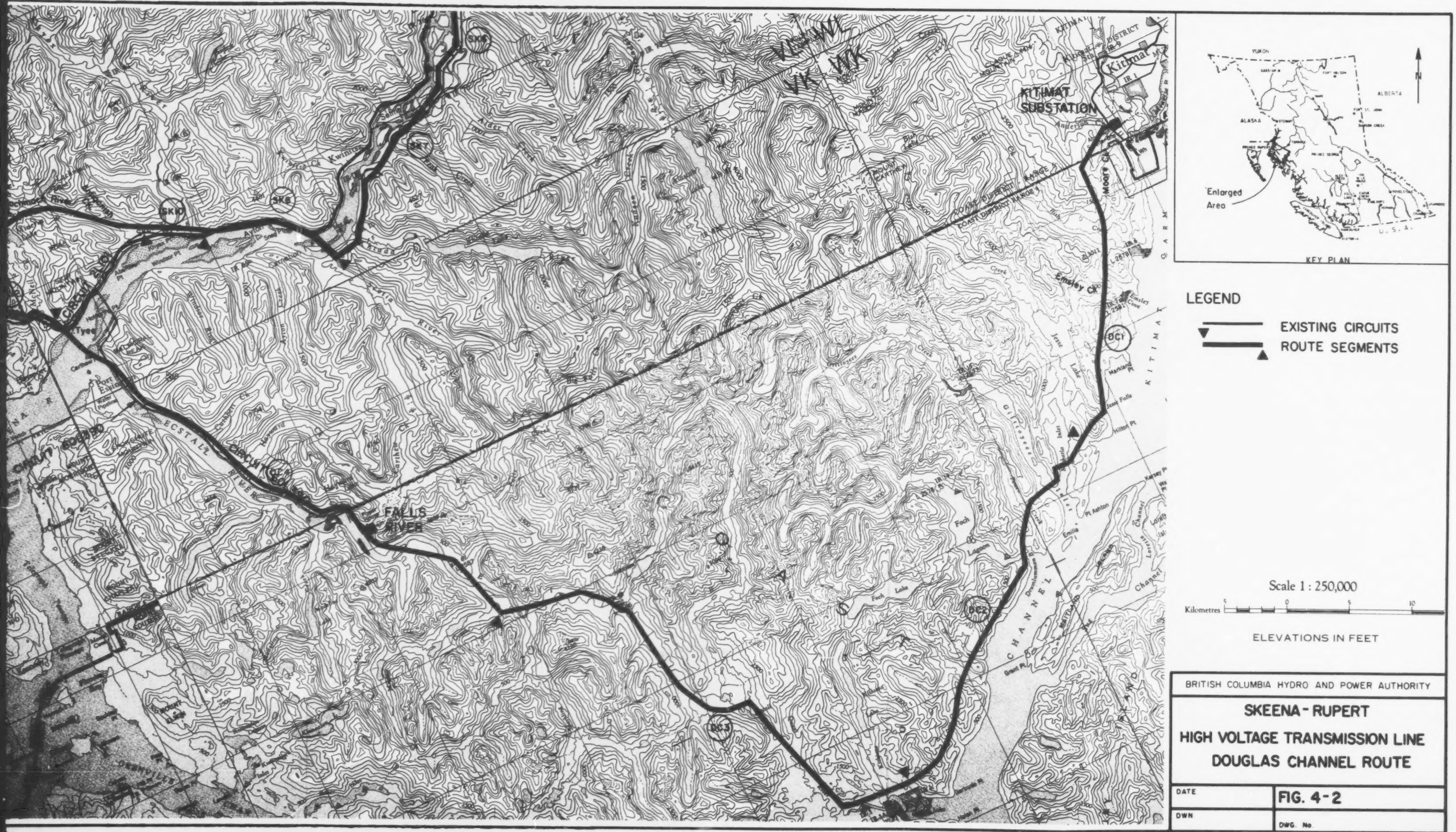
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
SKEENA RIVER ROUTE

DATE	FIG. 4-1
DWN	DWG. No

REPORT No

CHANNEL
PRINCE RUPERT SUBSTATION
Prince Rupert
Port Edward
Tyee
Port Essington
Lochmaack River
Ecstall
DeHorsey Island
Marcus Passage
Malacca Passage
Arthur Passage
Telegraph Passage
Porpoise Island
Smith Inlet
Humpback Inlet
Useless Inlet
Kennedy
Lewis I.
Cranberry Creek
Ridley Island
Lelu
Digby I.
Kaien Island
Hays Creek
Skeena River
SK10
SK11
SK12
SK13
SK14
SK15
SK16
SK17
SK18
SK19
SK20
SK21
SK22
SK23
SK24
SK25
SK26
SK27
SK28
SK29
SK30
SK31
SK32
SK33
SK34
SK35
SK36
SK37
SK38
SK39
SK40
SK41
SK42
SK43
SK44
SK45
SK46
SK47
SK48
SK49
SK50
SK51
SK52
SK53
SK54
SK55
SK56
SK57
SK58
SK59
SK60
SK61
SK62
SK63
SK64
SK65
SK66
SK67
SK68
SK69
SK70
SK71
SK72
SK73
SK74
SK75
SK76
SK77
SK78
SK79
SK80
SK81
SK82
SK83
SK84
SK85
SK86
SK87
SK88
SK89
SK90
SK91
SK92
SK93
SK94
SK95
SK96
SK97
SK98
SK99
SK100


KITIMAT SUBSTATION
Kitimat
IR 1
KITIMAT DISTRICT
IR 9
Kitimat Mtn
Moore Ck
Emsley Ck
Emsley Cove
Jesse Lake
Jesse Falls
Hilton Pt
Pt Ashton
Kitimat Arm
Douglas Channel
Fiordland Inlet
Fiordland Lagoon
Fiordland Pt
Grant Pt
Kwinitsa
Kwinitsa Ck
Skeena River
Ayton Creek
Ayton
Terrace
Kitselas Canyon
Kitselas Ck
Kitsumkalum
Kitsumkalum Ck
Kitsumkalum Lake
Kitsumkalum Mtn
Kitsumkalum Provincial Park
Kitsumkalum Provincial Park Addition
Kitsumkalum Provincial Park Addition No. 2
Kitsumkalum Provincial Park Addition No. 3
Kitsumkalum Provincial Park Addition No. 4
Kitsumkalum Provincial Park Addition No. 5
Kitsumkalum Provincial Park Addition No. 6
Kitsumkalum Provincial Park Addition No. 7
Kitsumkalum Provincial Park Addition No.

SECTION 5.0 - ROUTE EVALUATION

5.1 INTRODUCTION

One of the most important steps in the selection of a transmission line route is a detailed evaluation of the various feasible route alternatives with the objective of determining the least costly and the most secure route. This is best accomplished by evaluating each segment on the basis of specific technical, cost and hazard criteria. The segments thus can be consistently compared and the set of segments which best meets this objective can be selected to form the overall technically preferred route.

The segment evaluation was primarily accomplished by a detailed examination of aerial photography. Three different sets of aerial photographs of the Skeena valley routes were obtained. These included 1976, 1979 and 1980 photography at approximate scales of 1:12 000, 1:25 000 and 1:10 000 respectively. The 1980 photographs were in colour.

Federal government photography at an approximate scale of 1:20 000 was obtained for the Douglas Channel route between Kitimat and Falls River. Lower level, colour photography at an approximate scale of 1:12 000 was obtained between Falls River and Tyee.

In addition to the airphoto studies an independent consultant was obtained to map the Skeena River route at a scale of 1:50 000 utilizing the 1980 photography. The objective of this mapping was to obtain the most up-to-date topographic detail, particularly of the constantly changing river islands and channels. This enabled comparisons to be made with published topographic maps compiled from older aerial photography to determine where the most significant river and creek erosion

hazards existed. The mapping also provided information of the most recent road access and logging activity.

On the basis of the airphoto interpretation and map studies, the various hazards and technically difficult areas were identified. These were then closely examined by ground and aerial reconnaissance.

The following subsections include a segment by segment evaluation on the basis of technical, cost and hazard criteria.

5.2 TECHNICAL EVALUATION

(a) Technical Evaluation Criteria

The technical evaluation of each segment includes an assessment of four engineering components: design, access, clearing and special considerations. The primary objective of separating the technical evaluation into these components is to provide information for estimating the relative cost of construction for each segment. However, the evaluation is also a useful method for consistently ranking each segment as to its construction suitability and to enable choices to be made between alternatives.

The criteria used for assigning a specific rank to each segment for each of the four evaluation components is shown on Table 5-1. A description of the four evaluation components is as follows:

1. Design - There are three main independent factors influencing the design of a transmission line. These include:

EVALUATION COMPONENTS		RATINGS				
		LOW ——— EXTREME				
		I	II	III	IV	V
	DESIGN CONSIDERATIONS - Topography - Conductor Loading - Deflections	- no sidehill - light loading - low percent of defl	- rolling, some sidehill - light loading - medium percent of defl	- 30° average sidehill - medium loading - med-high percent of defl	- over 30° average sidehill - high loading - high percent of defl	- extreme sidehill - extreme loading - individual site selection
	ACCESS	Good existing access from other linear developments	Access to R/W at frequent points not far from existing roads. New road construction easy	Some access; new road construction possible	No existing access; new road construction difficult	Inaccessible to vehicles
	CLEARING	Little clearing; range land with scattered individual trees	Easy machine clearing	Moderate machine clearing; some hand clearing	Extensive hand clearing; forests that will not be logged	Totally hand clearing; steep, densely forested slopes
	SPECIAL CONSIDERATIONS	None	minimal	moderate	high	extreme

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
TECHNICAL EVALUATION CRITERIA

DATE

TABLE 5-1

DWN

DWG No

REPORT No

a. Topography - The more severe the sideslope the more difficult and expensive the line is to construct. In order to maintain the necessary clearance between the conductors and ground in these conditions taller structures are necessary or structure spacing is reduced. As a result more structures are required. Longer leg extensions on the structures are necessary and structure sites may need more prepatory work.

b. Loading - If severe ice and wind loadings are anticipated the conductor, structures and hardware must be heavier, resulting in higher costs.

c. Line Deflections - Line deflections require heavier than normal structures. Deflections exceeding approximately 25° also require additional insulator strings and conductor hardware. The greater the percentage of large deflection angles the more expensive the line becomes.

2. Access - The ratings for access reflect two important considerations. The first is the availability of existing access along or near major portions of the proposed route. This access is important for the transportation of materials and equipment to and from the vicinity of the line. The second is the accessibility of the individual tower sites. In some areas access to each site can easily be gained by constructing spur roads or temporary facilities. In rough terrain these facilities may be extremely difficult to construct and other methods of accessing the structure site must be found.

PHOTO 5-1 — Typical snowlegs used on 500 kV structures to reinforce against snow movement.

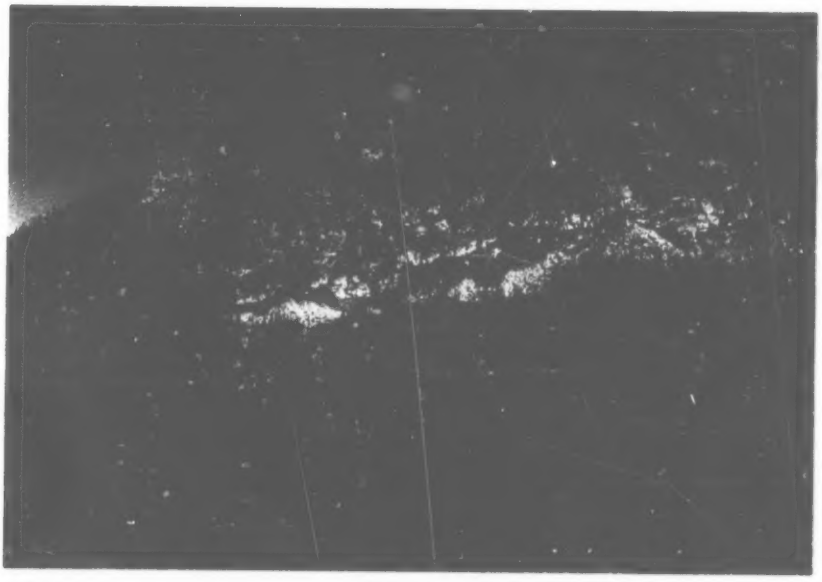


PHOTO 5-2 — Specialized single mast structures which can be used in terrain with severely limited tower sites.

3. Clearing - Clearing costs increase in areas which cannot be cleared by machinery due to their inaccessibility, rugged or wet terrain, susceptibility to erosion or water course pollution or special property concerns. In these areas clearing is accomplished using hand held equipment.

   The method and type of clearing is an important evaluation component because of its significance in erosion problems, right-of-way maintenance, environmental sensitivity and land use concerns.

4. Special Considerations - Specialized structures or construction techniques result in greater expense. This includes spans exceeding approximately 1000 m, special foundations, structure legs designed to withstand snow movement, snow legs, avalanche protection, special conductors, and special structures such as single phase towers, double circuit towers or anything that would warrant special construction.

(b) Segment Evaluation

The technical ratings for each of the 14 segments which make up the Skeena River route and the four which make up the Douglas Channel route are shown on Table 5-2. The length of each segment is also indicated.

It should be noted that the technical ratings should not be averaged for comparison with other segments because of the varying relative significance of each component and differing segment lengths. Roman numeral designations have been used in the evaluation criteria to dissuade any arithmetic derivations. However, some general observations can be made. If three or more components are rated I or II transmission construction along the segment would be generally easy and inexpensive. If the majority

SEGMENT		SK1	SK2	SK3	SK4	SK5	SK6	SK7	SK8	SK9	SK10	SK11	SK12	SK13	SK14	DC1	DC2	DC3	DC4
LENGTH (km)		12.5	19	19	21	7	7	18.5	12	11.5	5	10	13.5	23	7.5	23	39	35	44
EVALUATION COMPONENTS	DESIGN CONSIDERATIONS	II	IV	III	IV	III	II	IV	IV	IV	IV	V	V	III	IV	IV	V	II	IV
	ACCESS	II	50%I 50%IV	I	60%I 40%IV	50%I 50%V	IV	V	IV	V	II	IV	III	50%III 50%IV	III	IV-V	V	IV	V
	CLEARING	III	III	III	III	IV	IV	V	V	V	III	V	IV	IV	IV	IV	V	IV	V
	SPECIAL CONSIDERATIONS	II	IV	III	IV	IV	II	IV	V	V	III	IV	III	IV	II	III	IV	IV	V

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 5-1 (TECHNICAL EVALUATION CRITERIA)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
TECHNICAL EVALUATION

DATE

TABLE 5-2

DWN

DWG No

REPORT No

are given a rating of III the indication is average construction suitability and cost. Ratings of IV and V indicate difficult and costly construction. If most of the components are rated V then more suitable alternatives are usually sought, however, construction is not impossible. The infeasible route alternatives are eliminated prior to the evaluation stage based on engineering judgement and experience.

The following is a brief segment by segment elaboration of the significant factors contributing to the ratings given in Table 5-2.

(i) Skeena River Route

1. Segment SK1 - There are no significant technical factors to consider in this segment. The moderately rolling terrain, extensive logged areas, good access and lack of significant river crossings account for the low ratings.

2. Segment SK2 - This segment has a very high special considerations rating due to the possible requirement of two special river crossings and severe erosion problems requiring protection at Dasque Creek. The existing access is relatively good for approximately half of the segment and barge access is required for most of the remainder. A proportionately large number of deadend structures results in a high design rating.

3. Segment SK3 - All ratings in this segment are low to moderate. A rating of I for access was assigned because the segment closely parallels highway 16 for most of its length. The remainder of the ratings were moderate despite the swampy terrain. This was due primarily to the moderating effect of good access.

PHOTO 5-3 — Segment SK4. View of typical river islands and gravel bars traversed by 40% of segment.

PHOTO 5-4 — Segment SK4 at Exchamsiks. Special tower sites are required in river channel adjacent to CNR to skirt bluff in center of photo.

4. Segment SK4 - This segment is a moderately difficult segment for two reasons. Firstly, forty percent of the segment is located on river islands and two crossings of the main channel are required with extensive hand clearing and possibly some pile footings. Secondly the Exchamsiks River bluffs must be bypassed or traversed, both using specially prepared tower sites. These factors result in a rating of IV for special considerations and design. A split rating of I and IV was given for access for the portions parallel to Highway 16 and isolated river island portions respectively.

5. Segment SK5 - High ratings were given for the access, clearing and special consideration components because most of the segment traverses a series of small eroding islands and gravel bars in the main channel of the Skeena River requiring specialized towers and footings.

6. Segment SK6 - Like segment SK5 high ratings were given for access and clearing because most of the segment traverses river islands. These islands however, are stable, and require no specialized construction. Hence the low ratings for design and special considerations.

7. Segment SK7 - Construction along segment SK7 would be very difficult due to the steep, inaccessible terrain and the requirement for the line to be mostly located above the existing line which follows a sinuous route immediately adjacent to the Skeena River. Extensive avalanche protection will also be required. This results in high to very high ratings for all components.

PHOTO 5-5 — Rough, inaccessible terrain typical of segment SK11.

8. Segment SK8 - This segment is one of the more difficult segments of the Skeena River route. Most components have ratings of V because of the steep rocky terrain, the need for special river crossing towers and avalanche protection. Although the segment is inaccessible to vehicles a rating of IV for access was given due to the close proximity of Highway 16.

9. Segment SK9 - This segment has similar technical ratings to segment SK8. The river crossing is more difficult possibly requiring three or four special crossing towers.

10. Segment SK10 - Most components were given a low rating due to the flat terrain and close proximity to Highway 16. A rating of III was given for clearing because the choice of machine clearing versus hand clearing would be dependent on water levels. The segment is low lying and is susceptible to high water levels at certain times of the year. The reason for the high rating for design considerations is the anticipation of heavy ice loading in the area.

11. Segment SK11 - For the most part, segment SK11 is steep, rocky, heavily forested and inaccessible. This results in a very high rating for clearing and a high rating for access. Heavy ice loadings are also anticipated resulting in a very high rating for design.

12. Segment SK12 - Although segment SK12 is close to highway 16 and the terrain is less rugged the ratings are relatively high. The rating of V for design considerations is very significant because of the large number of deadend structures required in paralleling the existing woodpole line. A rating of IV for clearing is a result

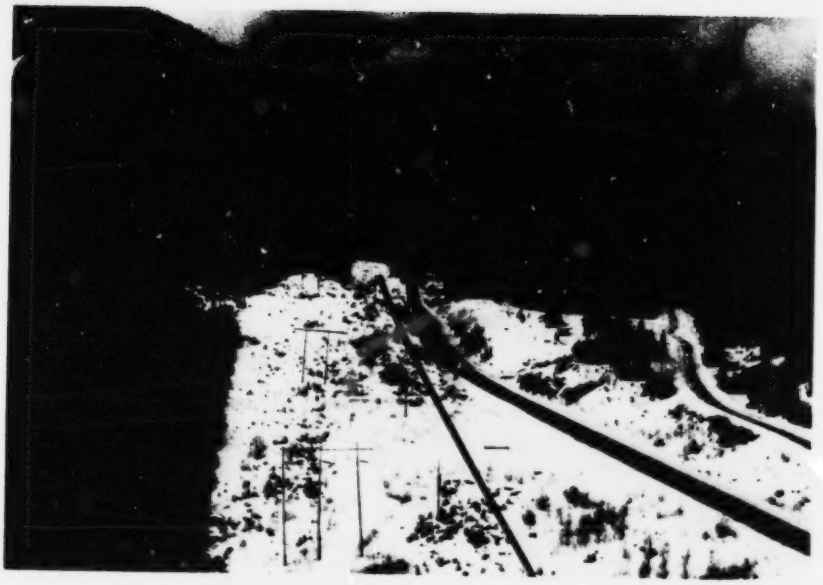


PHOTO 5-6 — Segment SK12. Possible relocation of 60L390 to accommodate new circuit between Highway 16 and 287 kV line may be required.

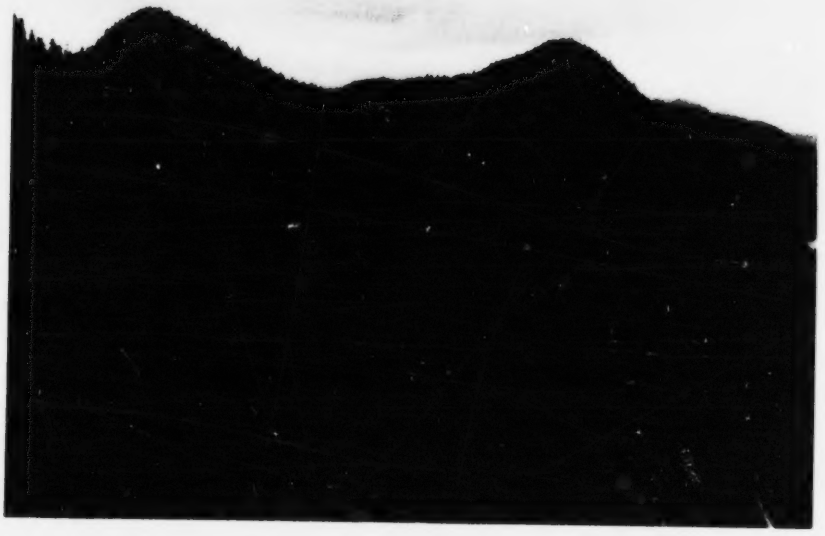


PHOTO 5-7 — Segment SK13. Logging access in Lachmach valley near Work Channel.

of the extensive wet, boggy areas along the segment. These are interspersed with numerous rock outcrops which make machine clearing difficult. Circuit 60L390 may require relocation in certain areas.

13. Segment SK13 - Most components were rated moderately high because the route traverses rugged, not easily accessible terrain except for some useable logging access in the Lachmach Valley. The main problem with the segment other than poor access is the extensive area of swamp or muskeg overlying bedrock. This could result in hand clearing and possible pile foundations. Hence high ratings for clearing and special considerations result. However, the route is relatively straight thus requiring few deadend structures. This results in a moderate rating for design.

14. Segment SK14 - This is a relatively short segment. For the most part this segment is similiar to segment SK12. High ratings for design and clearing is a result of closely following the existing line and traversing wet, swampy ground.

(ii) Douglas Channel Route

1. Segment DC1 - This segment is relatively straight, crossing rolling mountain topography with no major river or inlet crossings. The steep forested terrain and lack of existing access result in high ratings for clearing and access. However some access road construction may be possible over portions of the segment. The high rating for design considerations is due to anticipated heavy icing conditions.

PHOTO 5-8 — Segment DC3. Typical swampy terrain along high proportion of segment. Pile foundations may be required.

2. Segment DC2 - All components in this segment were given high to very high ratings. The terrain is very rough and isolated. Access road construction would be extremely difficult. Also there are three major crossings of inlets and numerous exposed areas with possible high ice and wind loadings.

3. Segment DC3 - Compared to the other Douglas Channel segments, this portion of the route appears to be relatively easy because of the moderately flat terrain. This should result in low ratings, however, due to the large areas of swamp and the isolation of the area, high ratings were given for access and clearing. The rating of IV for special considerations is due to the possibility that numerous pile foundations may be required.

4. Segment DC4 - Segment DC4 is a very difficult segment for transmission line construction. High to very high ratings were given for most components because of the steep, sinuous terrain encountered along the western shore of the Ecstall River above the Falls River 69 kV line. Access road construction is virtually impossible throughout. The special considerations include numerous relocations of the 69 kV line, a long crossing of the Skeena River in a heavy icing area and the possibility that avalanche protection and pile footings may be required at a number of locations.

5.3 COST ESTIMATES

The costs associated with constructing a transmission line are separated into direct costs and indirect costs. Direct costs include:

1. Engineering and Survey,
2. Right-of-way Aquisition and Legal Survey,
3. Clearing,
4. Materials,
5. Construction, and
6. Contingencies

Indirect costs include:

1. Inflation,
2. Corporate Overhead, and
3. Interest During Construction.

Direct and indirect segment cost estimates for both the 500 kV and 287 kV schemes are shown on Tables 5-3 and 5-4. Station costs and annual costs such as line losses, operation and maintenance are not included.

The costs shown were based on 1982 construction costs for similiar transmission lines and adjusted according to the four evaluation components discussed in Section 5.2. The following in-service dates were assumed:

Scheme 1:	500 kV - Skeena River Route	1988
Scheme 2:	287 kV - Skeena River Route	1988
	287 kV - Douglas Channel Route	1997

SKEENA-RUPERT 500 KV
1988 IN SERVICE DATE

ROUTE SEGMENTS	LENGTH (km)	ENGINEERING AND SURVEY	R/W AQUISITION AND SURVEY	CLEARING	MATERIALS	CONSTRUCTION	CONTINGENCY	DIRECT-COSTS TOTAL UNINFLATED	DIRECT-COSTS TOTAL INFLATED	CORPORATE OVERHEAD	INTEREST DURING CONSTRUCION	TOTAL SEGMENT COSTS	REMARKS
SK1	12.5	237	130	274	1440	1422	526	4029	6313	564	916	7793	-
2	19	610	198	829	3497	5616	1613	12363	19370	1732	2810	23912	-
3	19	522	198	1000	3135	4757	1442	11054	17319	1548	2513	21380	-
4	21	680	218	844	3955	6236	1790	13723	21501	1922	3119	26542	-
5	7	200	73	328	1837	2393	725	5556	8705	778	1263	10746	-
6	7	170	73	328	1677	2193	666	5107	8002	715	1161	9878	-
7	18.5	556	193	867	3904	6166	1753	13439	21056	1882	3055	25993	-
8	11	328	114	516	2310	3372	996	7636	11964	1069	1736	14769	-
9	11.5	346	120	539	2512	3611	1069	8197	12843	1148	1863	15854	-
10	5	93	52	233	731	995	316	2420	3792	339	550	4681	-
11	10	300	104	475	1533	2315	709	5436	8518	762	1236	10516	-
12	13.5	366	141	588	2163	3319	987	7564	11853	1055	1719	14627	-
13	23	667	239	1336	3178	4276	1454	11150	17472	1555	2533	21560	-
14	7.5	139	78	329	1172	1643	504	3865	6056	541	879	7476	-

NOTE: UNINFLATED COSTS SHOWN IN 1982 THOUSAND DOLLAR UNITS.

BC Hydro

SKEENA-RUPERT
HIGH VOLTAGE TRANSMISSION LINE
SEGMENT COST ESTIMATES
SCHEME 1

DATE	TABLE 5-3
DWN.	DWG. No.

B

SKEENA-RUPERT 287 KV
1988 IN SERVICE DATE

ROUTE SEGMENTS	LENGTH (km)	ENGINEERING AND SURVEY	R/W AQUISITION AND SURVEY	CLEARING	MATERIALS	CONSTRUCTION	CONTINGENCY	DIRECT-COSTS TOTAL UNINFLATED	DIRECT-COSTS TOTAL INFLATED	CORPORATE OVERHEAD	INTEREST DURING CONSTRUCTION	TOTAL SEGMENT COSTS	REMARKS
SK1	12.5	177	118	114	665	628	255	1957	3052	547	472	4071	-
2	19	527	180	384	1996	3277	955	7319	11415	2045	1767	15227	-
3	19	445	180	888	1695	2609	873	6690	10434	1869	1615	13918	-
4	21	587	199	703	2296	3648	1115	8548	13332	2389	2064	17785	-
5	7	199	66	273	1358	1777	551	4224	6588	1180	1019	8787	-
6	7	169	66	219	1198	1577	484	3713	5791	1038	896	7725	-
7	18.5	571	175	437	2346	3766	1094	8389	10384	2344	2025	17453	-
8	11	335	104	258	1383	1945	604	4629	7219	1294	1118	9361	-
9	11.5	355	109	492	1544	2119	693	5312	8285	1484	1282	11051	-
10	5	93	47	106	374	555	176	1351	2107	378	326	2811	-
11	10	256	95	179	827	1426	418	3201	4992	894	773	6659	-
12	13.5	232	128	249	774	888	341	2612	4074	730	631	5435	-
13	23	587	217	1168	2012	3269	1088	8341	13009	2331	2014	17354	-
14	7.5	103	71	153	492	518	201	1538	2399	430	371	3200	

KITIMAT-RUPERT 287 KV
1997 IN SERVICE DATE

ROUTE SEGMENTS	LENGTH (km)	ENGINEERING AND SURVEY	R/W AQUISITION AND SURVEY	CLEARING	MATERIALS	CONSTRUCTION	CONTINGENCY	DIRECT-COSTS TOTAL UNINFLATED	DIRECT-COSTS TOTAL INFLATED	CORPORATE OVERHEAD	INTEREST DURING CONSTRUCTION	TOTAL SEGMENT COSTS	REMARKS
DC1	23	597	193	1673	2252	3719	1265	9699	32443	3761	5347	41551	
DC2	39	1299	328	2788	4544	7712	2501	19172	64131	7433	10570	82134	
DC3	35	1056	294	2788	3651	6233	2103	16125	53939	6252	8890	69081	
DC4	44	1262	370	3345	4673	7678	2599	19927	66656	7726	10986	85368	
SK12	13.5	232	128	249	774	888	341	2612	8737	1013	1440	11190	
SK14	7.5	103	71	153	492	518	201	1538	5145	596	848	6589	

NOTE: UNINFLATED COSTS SHOWN IN 1982 THOUSAND DOLLAR UNITS.

BC Hydro

SKEENA-RUPERT
HIGH VOLTAGE TRANSMISSION LINE
SEGMENT COST ESTIMATES
SCHEME 2

DATE	TABLE 5-4
DWN.	DWG. No.

B

5.4 HAZARD EVALUATION

(a) Hazard Evaluation Criteria

There are four major hazards to transmission facilities in British Columbia: snow avalanche, slope failure, flood and river erosion and high ice and wind loading. There are numerous other hazards which can cause damage to transmission lines, however, most of these are relatively rare.

Table 5-5 lists the criteria used for ranking the segments according to the relative severity of the four major hazards. Five categories from low to extreme are used for each hazard. The criteria is heavily dependent on the type of terrain and climatic conditions required for the hazard to occur during the life of the line. Also the severity of the hazard is dependent on the ability to select an alignment within the route which can partially or totally avoid the hazard.

Account has not been made in the criteria of the expected frequency of occurrence of the specific hazards. To do this, extensive data must be collected over a period of years. This is both impractical and expensive for most route selection studies. Also the effect of protection devices on the hazard rating has not been considered because of the diversity of devices available and the potential cost involved. Security devices are normally considered only after the optimum route and specific tower sites have been selected.

The following is a general description of each hazard as it relates to transmission lines, the type of terrain where the hazard can be expected and possible defense measures that can be taken.

		I ZERO - VERY LOW	II LOW	III MODERATE	IV HIGH	V EXTREME
AVALANCHE		LITTLE SNOW ACCUMULATION. SLOPES < 10°-30°, TREE COVERED REMOTE POSSIBILITY OF OCCURANCE	SNOW ACCUMULATION < 1.5 m SLOPE ANGLES < 30° OR > 50° NO EXISTING AVALANCHE PATHS. POSSIBILITY OF OCCURANCE ON OPEN SLOPE DURING UNUSUALLY HEAVY SNOW FALL	STARTING ZONE: - SNOW DEPTH > 1.5 m - SLOPE ANGLE 30°-50° - TREE COVERED A FEW CONFINED AVALANCHE PATHS. POSSIBILITY OF SPANNING OR PASSING NEAR ENDS OF RUNOUT ZONES	STARTING ZONE: -SNOW DEPTH > 1.5 m -SLOPE ANGLE 30°-50° -BARE OF TREES NUMEROUS, CONFINED AVALANCHE PATHS AT LEAST ONE LARGE AVALANCHE/PATH/YR AVOIDANCE OF MOST PATHS DIFFICULT	STARTING ZONE: -SNOW DEPTH > 1.5 m -SLOPE ANGLE 30°-50° -BARE OF TREES NUMEROUS, INTERFINGERING OR UNCONFINED AVALANCHE PATHS. MORE THAN ONE LARGE AVALANCHE/PATH/YR. NO POSSIBILITY OF SPANNING OR AVOIDING PATHS.
SLOPE FAILURE	LANDSLIDE	FLAT TO MODERATE TERRAIN WELL DRAINED, GENERALLY HOMOGENIOUS MATERIAL OR BEDROCK	FLAT TO MODERATE TERRAIN, FLOOD PLAIN, FAN OR DELTA. GENERALLY WELL DRAINED BUT MATERIAL NOT HOMOGENIOUS CAUSING LOCALIZED AREAS OF POOR DRAINAGE.	HILLY, GLACIATED TERRAIN-NUMEROUS SWAMPS LAKES, MEANDERING STREAMS. INTERBEDDED MATERIALS. DRAINAGE GENERALLY POOR. EXISTING FAILURES SMALL.	HILLY, GLACIATED TERRAIN, OLD LANDSLIDE DEPOSITS, INTERBEDDED MATERIALS OF HIGHLY VARYING PERMEABILITY, POOR DRAINAGE. SLOPES UNDERCUT BY EROSION. SOME LARGE EXISTING FAILURES.	AREA OF EXTENSIVE, RECENT LANDSLIDE ACTIVITY CHARACTERIZED BY TENSION CRACKS, BLOCKED DRAINAGE, SEEPAGE ZONES AND HUMMOCKY GROUND. MATERIAL CONTAINS FINE GRAINED SILT AND CLAY OR OVERLIES SHALE. AREA CANNOT BE AVOIDED.
	DEBRIS (MUD) FLOW	TERRAIN FLAT TO GENTLY ROLLING THICK SOIL MANTLE OVERLYING BEDROCK. MATERIAL WELL DRAINED. LIGHT RAINFALL OR SNOWMELT.	FLAT TO MODERATE TERRAIN WITH SLOPES < 25°. THIN MANTLE OF SOIL OVERLYING BEDROCK. LIGHT RAINFALL AND SNOWMELT.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK. POOR-MODERATE DRAINAGE. TREECOVER NOT REMOVED. PERIODS OF HEAVY RAINFALL. NO PREVIOUS SLIDES VISIBLE.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK, POOR DRAINAGE. AREA SUBJECT TO HIGH INTENSITY RAINFALL. TREE-COVER REMOVED BUT GROUNDCOVER RE-ESTABLISHED. SOME PREVIOUS SLIDES VISIBLE.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK, POOR DRAINAGE. AREA SUBJECT TO HIGH INTENSITY RAINFALL AND SNOWMELT. TREECOVER RECENTLY REMOVED OR SOIL MANTLE DISTURBED. NUMEROUS PREVIOUS SLIDES VISIBLE.
	ROCKFALL	FLAT TO GENTLY ROLLING TERRAIN. UNCONSOLIDATED MATERIAL OR GENTLY ROLLING BEDROCK AREAS.	GENTLY ROLLING TERRAIN WITH MODERATE SLOPES CONSISTING OF MASSIVE DISCONTINUOUSLY JOINTED ROCK NOT SUSCEPTABLE TO EROSION.	STEEP ROCK SLOPES > 20°. FAVOURABLE ORIENTATION OF JOINTS AND BEDDING. FEW FAULT ZONES, EXISTING ROCKFALLS CONFINED TO CHUTES AND GULLIES. SLOPE NOT UNDERCUT BY EROSION. GOOD POSSIBILITY OF AVOIDING EXISTING ROCKFALLS.	STEEP ROCK SLOPES > 20°. DOWNSLOPE ORIENTATION OF JOINTS OR BEDDING. NUMEROUS FAULT ZONES AND EXISTING ROCKFALLS. SLOPES NOT UNDERCUT BY BY EROSION ETC. SOME POSSIBILITY OF AVOIDING EXISTING ROCKFALLS.	STEEP ROCK SLOPES > 20°. DOWNSLOPE ORIENTATION OF JOINTS OR BEDDING. NUMEROUS FAULT ZONES AND EXISTING ROCKFALLS. SLOPE UNDERCUT BY RIVER EROSION OR CONSTRUCTION ACTIVITY GREAT DIFFICULTY OF AVOIDING EXISTING ROCKFALLS.
FLOOD AND RIVER EROSION		FLAT TO GENTLY ROLLING TERRAIN. A FEW WELL CONFINED STREAMS WITH REMOTE POSSIBILITY OF FLOODING OR COURSE CHANGE.	MODERATE TO STEEP TERRAIN. FEW INTERSECTING STREAMS WITH SOME POSSIBILITY OF FLOODING OR COURSE CHANGE.	OBLIQUE CROSSING OF WIDE FLOODPLAIN OF MAJOR CREEK OR RIVER PRONE TO FLOODING. A FEW STRUCTURES REQUIRED ON FLOODPLAIN OR SOME INTERSECTING STREAMS PRONE TO FLOODING OR COURSE CHANGE. SOME POSSIBILITY OF AVOIDANCE.	LINE LOCATED ON FLOODPLAIN. MOUNTAINOUS TERRAIN PRONE TO HIGH INTENSITY RAINFALL AND SNOWMELT. RIVER CHANNEL GENERALLY CONFINED BUT PRONE TO COURSE CHANGE. LINE CROSSES MOUTHS OF NUMEROUS STREAMS SUBJECT TO FLOODING OR COURSE CHANGE	LOCATED ON FLOODPLAIN. MOUNTAINOUS TERRAIN PRONE TO HIGH INTENSITY RAINFALL AND SNOWMELT. RIVER CHANNEL UNCONFINED AND PRONE TO PERIODIC COURSE CHANGE. FLOOD-PLAIN STREWN WITH DEBRIS.
ICE AND WIND LOADING		COMPLETELY SHELTERED. AIR MASSES GENERALLY DRY. TEMPERATURES RARELY BELOW FREEZING.	GENERALLY SHELTERED AND AT LOWER ELEVATIONS. SOME EXPOSURE TO MOIST AIR. PERIODIC TEMPERATURES BELOW FREEZING.	GENERALLY EXPOSED TO PREVAILING WINDS AND/OR MOIST AIR MASSES. SUSTAINED TEMPERATURES BELOW FREEZING.	MOSTLY EXPOSED TO PREVAILING WIND AND MOIST AIR MASSES. SUSTAINED TEMPERATURES BELOW FREEZING. LINE OBLIQUE OR PARALLEL TO PREVAILING WIND & GENERALLY ABOVE TREELINE OR AREA PRONE TO ENTRAPMENT OF COLD ARCTIC AIR BY MOIST COASTAL AIR.	COMPLETE TRANSVERSE EXPOSURE TO HIGH VELOCITY, PREVAILING WINDS, MOIST AIR MASSES AND SUSTAINED TEMPERATURES BELOW FREEZING.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA – RUPERT
HIGH VOLTAGE TRANSMISSION LINE
HAZARD EVALUATION CRITERIA

DATE

TABLE 5-5

DWN

DWG No

REPORT No

PHOTO 5-9 — Recent avalanche between structures on existing 287 kV circuit. Note protective berm above tower in foreground.

PHOTO 5-10 — Large avalanche blocking CNR and old highway near McLean Pt. New highway relocated into river channel to avoid frequent avalanches. For scale note immobilized train in background.

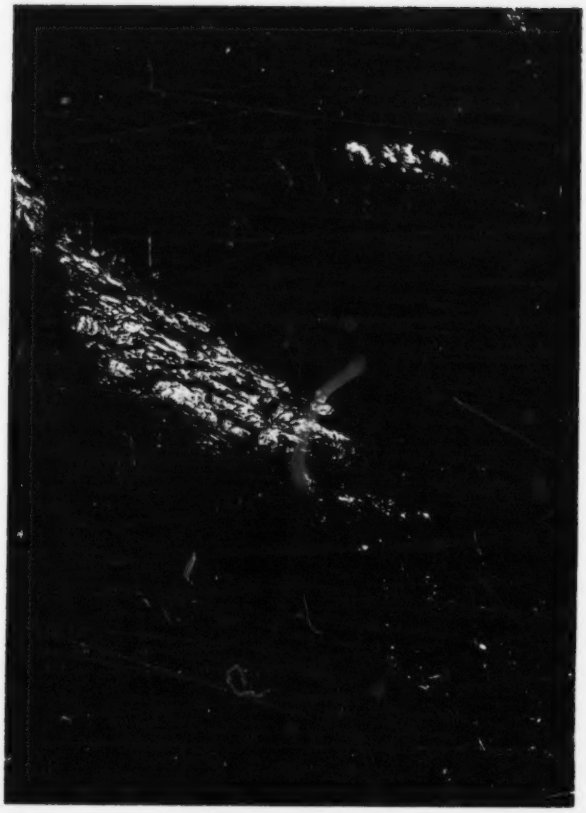
1. Snow Avalanche - Snow avalanches can be a severe hazard to transmission facilities because of their high velocities, impact pressures and associated airblast and debris-carrying characteristics.

Areas prone to avalanching generally have high local relief and abundant snowfall. Conditions critical for avalanche formation are slopes which average 30° to 50° and whose upper reaches or starting zones, are prone to snow accumulation of at least 1.5 m by either direct precipitation or wind accumulation. Starting zones are most often bare of trees and the most active collectors are horseshoe shaped bowls or gullies bounded by cliffs or ridges.

Avalanches usually flow in a defined track between the starting zone at the top and a runout zone at the bottom. These tracks can either be confined to a gulch or gully or be on unconfined planar open slopes. Starting zones must have the required steepness of 30° to 50°, however, avalanche tracks may include gentle slopes or level terrain. The runout zone is usually the valley floor but may extend up the opposite valley wall. Routes through narrow passes with numerous avalanche paths where runout zones interfinger or overlap are the most hazardous.

There are relatively few effective defences against avalanches for transmission lines. In some cases avalanche paths which run in confined gullies can be spanned, however, unconfined paths on planar slopes are difficult to span and are particularly dangerous.

Protection devices are usually limited to wedge shaped rock or earth berms placed uphill from the structure. These are designed to direct avalanches around the structure. Special



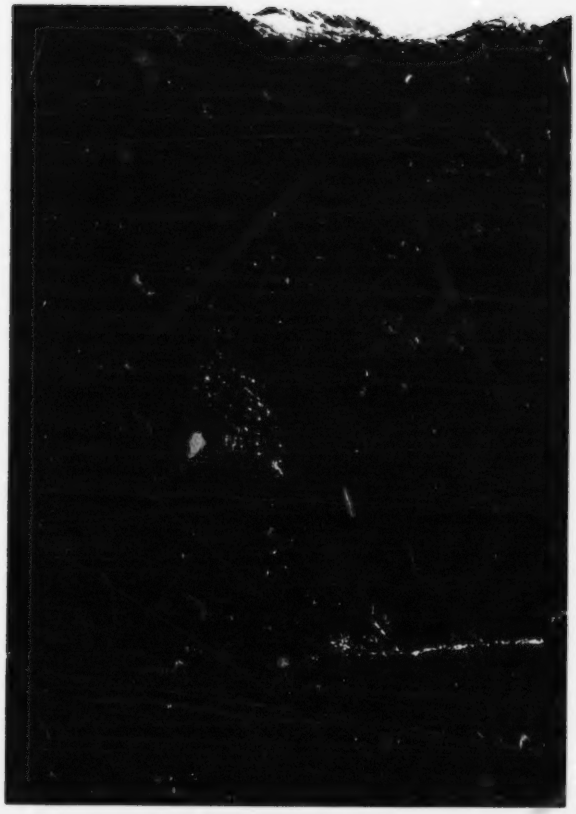


PHOTO 5-11 and 5-12 — Large scale debris flows along Douglas Channel (left) and Lachmach Valley (right).

steel and concrete deflection structures and reinforced tower legs can also be utilized. These devices usually only offer limited defense particularly when placed on slopes greater than 20° where large avalanches can easily override most protection devices.

Avoidance of avalanche paths and runout zones with transmission towers is the best defense against this hazard.

2. Slope Failure - There are numerous types of slope failures which can cause damage to a transmission line. These can include large scale landslides, debris flows, rockfalls and small scale slope failures caused by construction or logging activities. Areas with high local relief and abundant precipitation are particularly susceptible to slope failures, however, they can also occur on gentle slopes underlain by sensitive materials such as marine sediments and clayey till.

Large scale landslides must be avoided by transmission construction because of further large scale movement or small scale differential movement which cause destructive stresses on towers. Also because of the reduced shear strength of the landslide debris and the resultant disrupted drainage, access road construction and clearing may aggravate the soil movement. These activities may also cause small scale slope failures on previously stable ground underlain by sensitive silts and clays.

Debris flows involve the rapid downslope movement of water saturated soil and forest debris. They are particularly destructive to transmission lines. These are caused by the failure of a thin surface layer of water saturated, weathered and broken rock on steep slopes underlain by bedrock. Debris flows usually occur on cleared slopes of approximately 30° to

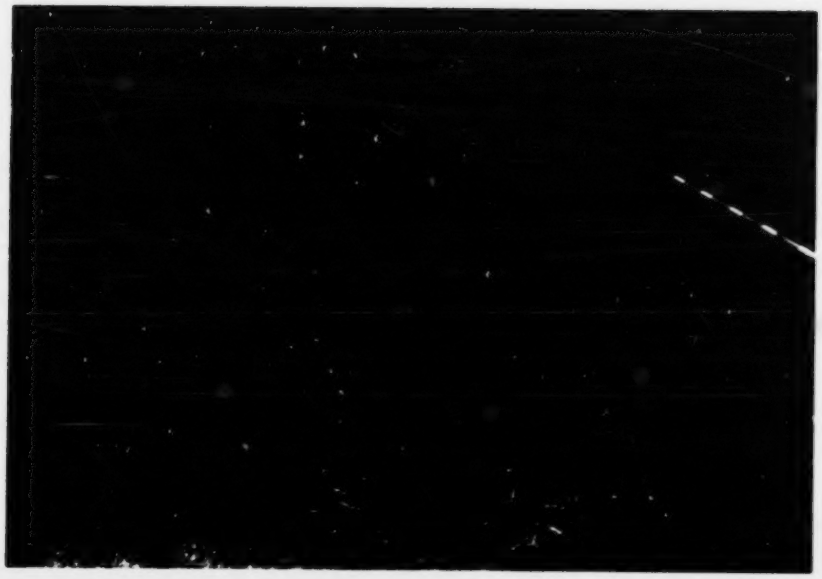


PHOTO 5-13 — Debris lodged against structure caused by flooding on islands along Skeena River.

PHOTO 5-14 — Typical rip-rap protection around structure near Dasque Creek to protect against river erosion.

35° and in areas of high intensity rainstorms. Slopes susceptible to this type of failure should be avoided if possible or special care must be taken in construction and clearing activities.

Severe damage to structures can occur by the downslope movement of large rocks and boulders. Slopes susceptible to rockfalls are those with downslope orientation of joints and bedding and along fault and scarp zones. Volcanic and sedimentary rocks are particularly susceptible.

3. Flood and River Erosion - Flooding and river erosion rank high in their destructive capability to transmission lines. Flood waters can undermine tower footings or cause damage with floating logs and debris. River and creek banks can be eroded hundreds of metres in a single flood and streams can change course dramatically in a few hours during heavy rainstorms and during snow melt.

   Securing towers against flood and erosion damage can be difficult, expensive and environmentally sensitive. Typical protective methods include surrounding towers with a sheet pile wall filled with rock, installing pile footings, constructing rip-rap protection, erecting dikes and diverting or modifying stream channels.

4. Ice and Wind Loading - Significant consideration is given to ice and wind loading during transmission line design and route selection. Ice accumulation and wind loading can cause collapse of towers and breakage of conductors or hardware.

   Large amounts of ice can form when fog or clouds pass slowly by structures and conductors at temperatures well below

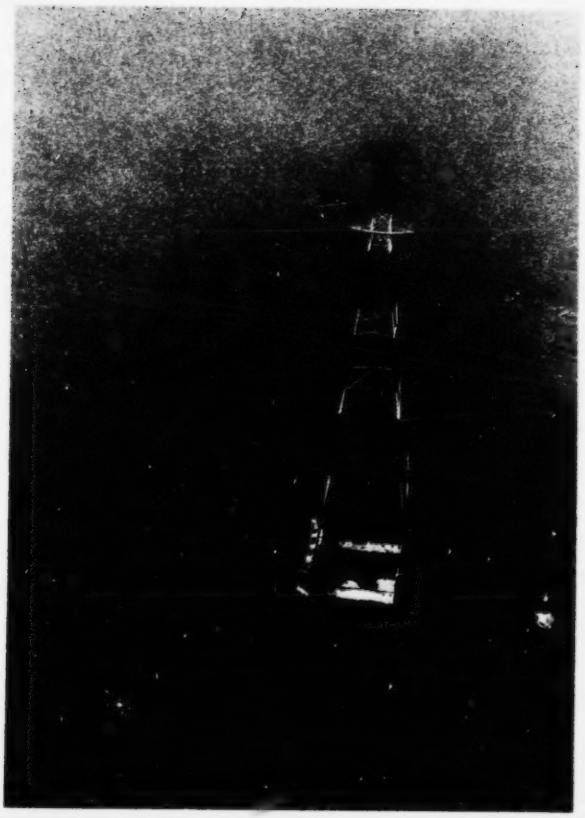


PHOTO 5-15 — Falls River 69 kV crossing of Skeena river near Tyee. Note damage caused to crossarm by excessive ice loading.

PHOTO 5-16 — Existing 287 kV river crossing at Carnation Island. Note remains of timber cribbing destroyed by river ice.

freezing or when moisture is deposited by freezing rain or drizzle in conjunction with freezing temperatures.

Strong winds and gusts can cause damage by imposing high loads on structures and conductors either by direct force or by setting the conductor in motion. This may result in circuit interruptions due to contact between conductors. Severe ice and wind loading can occur simultaneously and their combined effect can be devastating to transmission structures.

The meteorological phenomena of ice and wind loading is complex and areas prone to such conditions are difficult to outline without extensive long-term measurement and testing. However, certain terrain features and ambient air temperatures exercise considerable influence on the phenomena. Areas to avoid in transmission line construction are exposed ridges and narrow passes at high elevations where wind speeds are high and where passing clouds can envelope the structures. In coastal areas susceptible to cold northern air masses severe ice and wind conditions can occur at considerably lower elevations particularly where warm air can mix with or trap colder air in depressions and valleys.

Protection against ice and wind loading is restricted to installing stronger towers and conductors. These measures are extremely costly and complete security cannot always be assured. Areas of known extreme ice and wind conditions should therefore be avoided.

5. Other Hazards - Other hazards to transmission lines include snow creep, river ice, lightning strikes, forest fires, vehicular impact, construction activity and vandalism. These hazards can usually be adequately protected against using special design techniques or prudent structure location.

It is important to avoid placing two transmission lines serving the same area on a common right-of-way where hazards exist which might destroy both lines. Also, exposing the line to a hazard in an area where repairs may be difficult due to inaccessibility and poor weather conditions should be avoided. Higher security risks can be taken in more accessible areas.

(b) Segment Evaluation

Table 5-6 lists the segment by segment rankings according to the hazard evaluation criteria table.

As for the technical evaluation, an average overall hazard evaluation for each segment cannot be arithmetically derived because of the relative significance of each hazard. The hazards must be considered individually.

Ratings of I and II indicate that there is a remote possibility that a hazard would cause an outage during the life of the line. A moderate hazard rating (III) indicates that the specific hazard events can occur during the life of the line, however, under most circumstances prudent alignment and structure location can reduce the risk of damage to acceptable levels. Unusual events could occasionally damage the line.

A high (IV) rating indicates that the hazard affects a significant length of line or the possibility of avoiding an area where frequent hazards occur is difficult. Protection devices would almost certainly be required in these areas.

An extreme (V) hazard indicates an area where specific hazard events are frequent and there is no possibility of avoiding of the area. Protection devices may not ensure an adequate degree of security.

		SEGMENT	SK1	SK2	SK3	SK4	SK5	SK6	SK7	SK8	SK9	SK10	SK11	SK12	SK13	SK14	DC1	DC2	DC3	DC4
HAZARD		AVALANCHE	II	III-IV	II-III	III	II	III	V	IV-V	IV	II	III	III	IV-V	II	III	III	V	IV
	SLOPE FAILURE	LANDSLIDE	III	II	II	II	II	II	II	II	II	III	II	III	III	III	III	III	III	II
		DEBRIS (MUD) FLOW	II	IV	II	II	I	I	IV	V	III-IV	III	V	IV	V	III	III	III-IV	IV	IV
		ROCKFALL	I	III	III	III	I	I	III	III	III	II	III	III	III	II	III	III	II	IV
		FLOOD & RIVER EROSION	III	V	IV	IV	V	IV	IV	III	IV	II	III	II	IV	II	II	II	IV	III
		WIND & ICE LOADING	III	III	III	III	III	III	III	IV	IV	V	V	II	III	II	III-IV	V	III	IV

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 5-5 (HAZARD EVALUATION CRITERIA)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA – RUPERT
HIGH VOLTAGE TRANSMISSION LINE
HAZARD EVALUATION

DATE

TABLE 5-6

DWN

DWG No

REPORT No

PHOTO 5-17 — River erosion problem at Lakesle River. Note timber piles used for protection.

PHOTO 5-18 — River eroision problem at Whitebottom Creek. Note rip-rap protection.

An area which would normally receive a high rating may be rated extreme if two lines which service the same area are located on the same right-of-way in a hazardous zone. This would also be the case if access to the area is particularly difficult.

The following is a segment by segment elaboration of the ratings shown on Table 5-6. Avalanche hazards along the Skeena River route are indicated on Fig. 5-1.

(i) Skeena River Route

1. Segment SK1 - There are no significant hazards in this segment.

2. Segment SK2 - Moderate to extreme ratings for avalanche, debris flow and flood and river erosion are due to possible exposure to very large avalanches over a 2 km section 5 km west of Dasque Creek, debris flows 3 km west of Dasque Creek and severe flash flooding and river erosion at Whitebottom and Dasque creeks. Avoidance is very difficult at Dasque Creek due to constricting terrain and the position of the existing line.

3. Segment SK3 - Potential problems requiring erosion protection at the crossing of the Skeena River near Shames and at the mouth of the Exstew River result in a high rating for flood and river erosion.

4. Segment SK4 - Approximately 50 percent of the segment is located on islands prone to flooding in the main channel of the Skeena River resulting in a high rating for flood and river erosion.

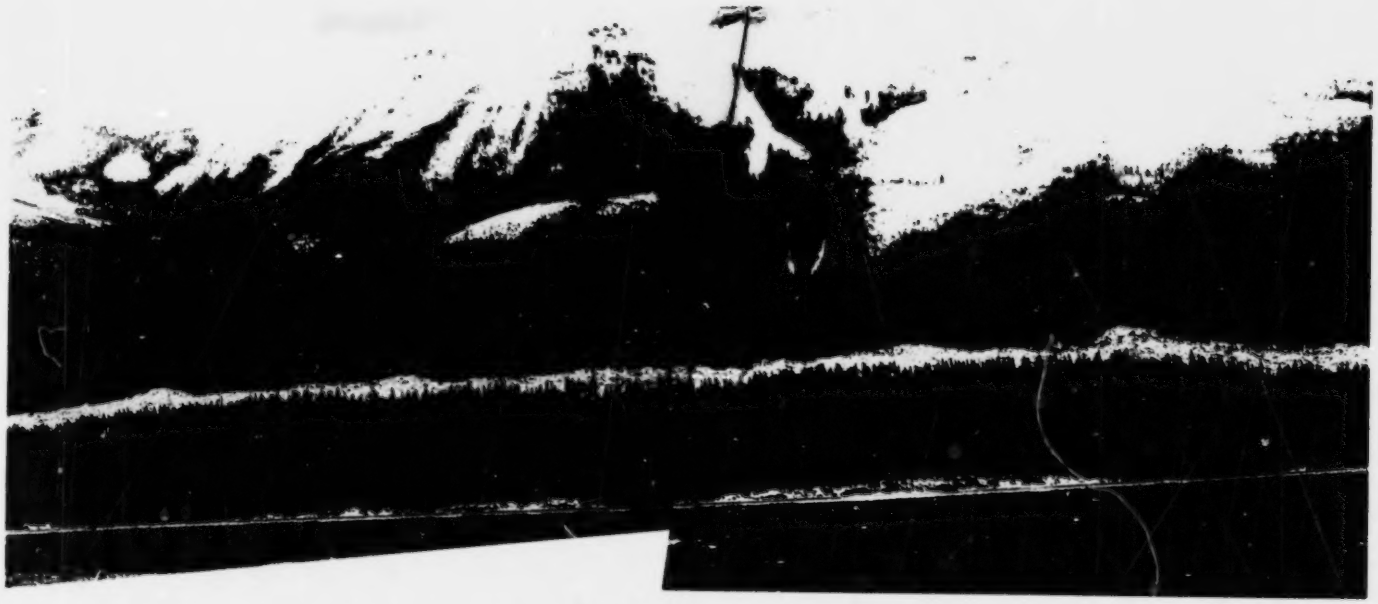


PHOTO 5-19 — Segment SK8. Large avalanche paths and starting zones above existing 287 kV line. Proposed line would be located below existing line in this segment.

5. Segment SK5 - The majority of the segment is located on shifting islands and gravel bars in the main channel of the Skeena at the mouth of the Kasiks River. This results in an extreme rating for flood and river erosion.

6. Segment SK6 - This segment has some of the same problems as segment SK5. However the river islands crossed in this segment are more stable resulting in a lower flood and river erosion rating.

7. Segment SK7 - This segment is parallel to the existing line across numerous avalanche paths and debris flows between Feak Creek and the existing crossing of the Skeena resulting in an extreme avalanche rating and a high debris flow rating. Also approximately 25 percent of the segment is located on river islands that show evidence of frequent flooding. This results in a high rating for flood and river erosion.

8. Segment SK8 - Moderate to extreme ratings for avalanche, debris flows and wind and ice loading were given. The majority of the segment is parallel to the existing line below a large avalanche zone. Existing avalanche paths, however are somewhat controlled by topography. This section is also steep and forested resulting in numerous debris flows which have started near the existing right-of-way. The rating for wind and ice loading is due to a transverse exposure to high winds flowing up the Skeena River from the west and frequent intermixing of warm coastal air and very cold air masses flowing down the Skeena River.

9. Segment SK9 - The moderate to high ratings for debris flow and avalanche are due to the crossing of a steep slope where existing flows and avalanches have occurred.

The hazard will increase after the right-of-way is cleared. The high rating for floods and river erosion is due to the long river crossing. Three or four special crossing towers will be required in the main channel of the Skeena. This area is also subject to movement of river ice during spring breakup. The high ice and wind loading rating is for reasons similiar to segment SK8.

10. Segment SK10 - The only significant hazard in this segment is for anticipated heavy ice loading.

11. Segment SK11 - This segment traverses a steep forested slope below the existing line where debris flows have originated on the existing right-of-way. The hazard is considered extreme. Heavy ice loadings have caused damage to both the existing 69 kV and 287 kV lines in this area. This results in an extreme rating.

12. Segment SK12 - This segment essentially has the same hazards as segment SK11. However, as the terrain is not as steep and is more sheltered, slightly lower ratings generally result.

13. Segment SK13 - Avalanche paths in the Lachmach valley and at the head of the Prudhomme valley, numerous existing debris flows which are aggravated by logging activity and numerous intersecting creeks subject to flooding result in high to extreme ratings.

14. Segment SK14 - There are no significant hazards in this segment.

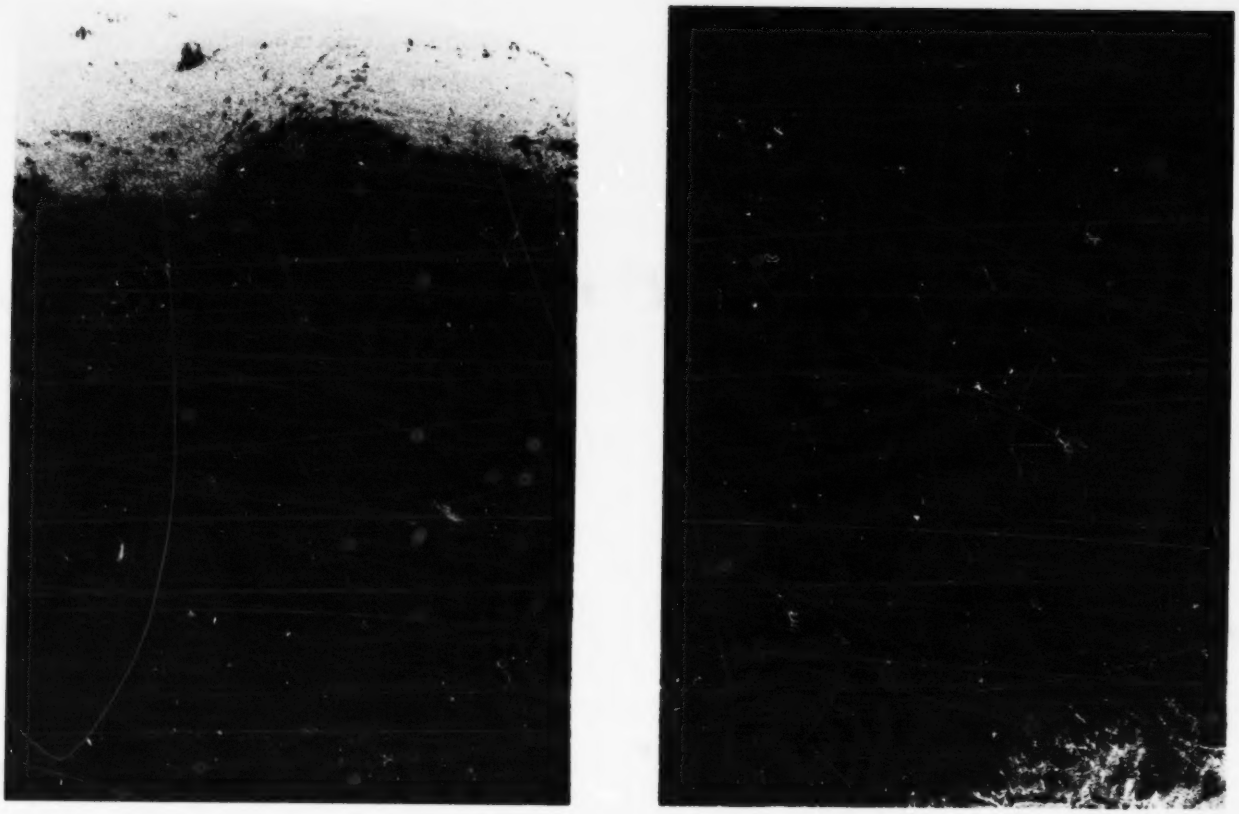


PHOTO 5-20 and 5-21 — Segment DC3. Large avalanche paths west of Johnstone Lake. Note devastation of large, mature timber caused by recent avalanching.

(ii) Douglas Channel Route

1. Segment DC1 - Some relatively high areas between Emsley Cove and Jesse Falls which are exposed to high winds flowing up Douglas Channel and possible high ice loading conditions contribute to a moderate to high rating.

2. Segment DC2 - The majority of the segment traverses steep forested slopes with a thin mantle of soil overlying bedrock between Foch Lagoon and Kitkiata Inlet. The debris flow hazard here is moderately high.

   The segment traverses an exposed ridge above Gertrude Point where high winds flowing up Douglas Channel from the south are deflected northeastward. There also are three major exposed crossings of inlets. The ice and wind loading hazard is considered extreme.

3. Segment DC3 - Segment DC3 must cross three or four large interfingering avalanche paths west of Johnston Lake thus an extreme hazard rating results.

   The east sides of Quaal River and Ecstall Lake show signs of debris flow activity which accounts for the high hazard rating. Also, the segment obliquely crosses meanders in the Quaal River which are subject to flooding.

4. Segment DC4 - This segment has high ratings for avalanche, debris flow and rockfall. Several large avalanche paths are crossed between Sparkling Creek and Falls River. Between Falls River and the Skeena steep forested slopes, some of which have been logged, show

signs of existing debris flows and rockfalls. The numerous rockfalls occur from steep bluffs with poorly oriented joints. The high rating for ice and wind loading is a result of possible ice loading occurring near the mouth of the Ecstall River. The 69 kV line in this area has been severely damaged by ice.

5.5 SEGMENT COMPARISON

(a) Skeena River Route

Due to a number of technical consideratons few route choices are available along many portions of the Skeena River valley. In terms of the route segments, these would be segments SK1, SK4, SK7, SK10 and SK14. Of the remaining segments some choice can be made on technical grounds as follows:

(i) Segment SK2 vs Segment SK3

Segment SK3 is superior. Of the two, segment SK3 would be the least costly [see Tables 5-3 and 5-4] due primarily to easier, more accessible terrain and fewer deadend structures. Also segment SK2 would require special structures to avoid the river erosion problem at Dasque Creek. This problem, plus a higher avalanche and debris flow rating, make segment SK2 far less secure than segment SK3.

(ii) Segment SK5 vs Segment SK6

Both segments are of equal length, however, segment SK6 is the least costly [see Tables 5-3 and 5-4]. This is due to the requirement for special structures in the main channel of the Skeena River near the mouth of the Kasiks River. This river

crossing is also less secure than the one along segment SK6 due to less stable river islands.

(iii) Segment SK8 vs Segment SK9

Segment SK8 is the technically preferred segment. It is 0.5 km shorter than SK9. The extra length plus the requirement for possibly two more special river crossing towers for the crossing near Ayton Island make segment SK9 more expensive.

Both segments generally received high to extreme technical and hazard ratings. Segment SK9 had slightly lower ratings for avalanche and debris flows. However, it had a much higher rating for flood and river erosion due to the crossing of the mouth of the Scotia River and the longer crossing at Ayton Island.

Segment SK8 is also superior due to the close proximity of highway 16 which would be a benefit during construction or in the event of damage due to a hazard. Segment SK9 is quite isolated on the south shore of the Skeena River.

(iv) Segments SK11 and SK12 vs Segment SK13

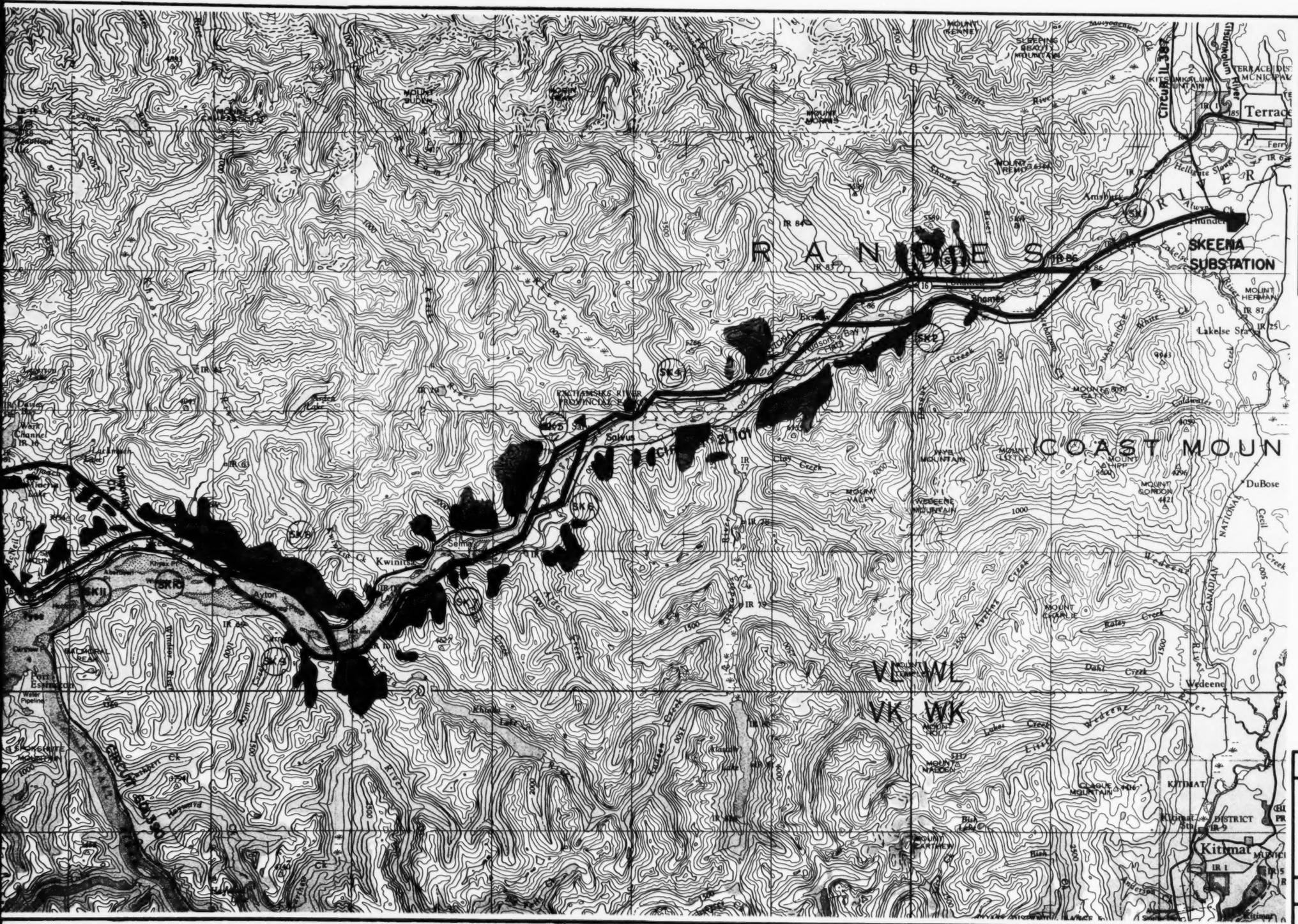
Segment SK13 is preferred on technical grounds. The combined length of segment SK11 and SK12 is approximately 0.5 km longer than segment SK13. In general the evaluation ratings for segments SK11 and SK12 are similiar to segment SK13. Segments SK11 and SK12 have better access and are not exposed to high avalanche and debris flow hazards as is segment SK13. However, segment SK11 and particularly SK12 have a high proportion of heavy angle and deadend structures because they parallel the existing woodpole 287 kV line. This results in

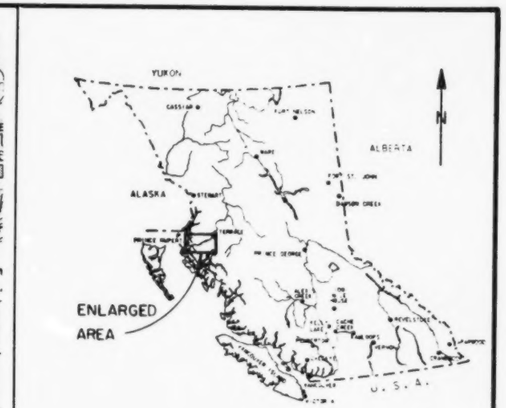
much higher cost. [See Tables 5-3 and 5-4.] Also segments SK11 and SK12 are more vulnerable to extreme ice and wind hazards.

(b) Douglas Channel Route

For the group of segments which comprise the Douglas Channel route no alternatives are available for the portion between Kitimat and the mouth of the Ecstall River. Beyond that point it would only be reasonable to follow segments SK12 and SK14 to Rupert substation.

PRINCE RUPERT
RUPERT SUBSTATION
WORK CHANNEL
CHANNEL
PENINSULA
KAIEN ISLAND
MT. HAYS
SHARP PEAK
MOUNT MORSE
Grace Pt
Port Edward
Ridley Island
Lelu I
Watson Island
Digby I
Tuck Inlet
Prince Rupert
Shawatlan Lake
Woodworth Lake
Diana Lake
Rainbow Lake
Lakelse Lake
Work Channel
Lachmach Lake
Kwinamass R
Kwinamass Ck
Khyex R
Khyex Pt
Ayton
Terrace
Kitsumkalum Lake
Kitsumkalum R
Kitsumkalum Ck
Skeena R
Skeena Mts
Kitimat Ranges
Kitimat Arm
Kitimat
Kitimat R
Kitimat Ck
Hirsch Creek
Hirsch Creek Pass
Hirsch Creek Park
Kitimat Pipeline
Kitimat Pipeline Corridor
Kitimat Pipeline Corridor Park
Kitimat Pipeline Corridor Park Reserve
Kitimat Pipeline Corridor Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park
Kitimat Pipeline Corridor Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve Park Reserve
Kitimat Pipeline Corridor Park Reserve





KEY PLAN

LEGEND

EXISTING CIRCUITS

ROUTE SEGMENTS

AVALANCHE HAZARD AREAS

Scale 1 : 250,000

Kilometres 0 5 5 10

ELEVATIONS IN FEET

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SKEENA - RUPERT
HIGH VOLTAGE TRANSMISSION LINE
SKEENA RIVER ROUTE
AVALANCHE HAZARD AREAS

DATE	FIG. 5-1
DWN	DWG. No

REPORT No

SECTION 6.0 - CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

(a) Unacceptable Routes

This report has addressed six possible route options for two schemes to provide additional and more secure power to the Prince Rupert area. [Refer to Fig. 3-2.] Four of these route options are not suitable for transmission line construction because they each cross more than two high mountain passes where severe hazards to transmission line construction and operation exist. An adequate degree of security cannot be attained along these routes. These include the Mt. Campagnolo, Exstew, Kasiks and Little Wedeene routes.

(b) Acceptable Routes

There are two acceptable routes available for supplying additional power to the Rupert area. These are the Skeena River route and the Douglas Channel route. [Refer to Figs. 4-1 and 4-2 respectively.]

The most technically suitable group of segments which would form the Skeena River route between Skeena substation and the Khyex River are segments SK1, SK3, SK4, SK6, SK7, SK8 and SK10. Approximately 57 percent of this section is located parallel to the existing 287 kV circuit which for the most part is located on the south shore of the Skeena River. The remainder of this section is located on the north shore of the Skeena River, generally parallel to the CNR and Highway 16, or on river islands. The principal reasons for not paralleling the existing line in these areas are high avalanche and river erosion hazards.

Between Khyex and Prudhomme Lake two route alternatives are available. These are either segments SK11 and SK12 which parallel Highway 16 and the existing 287 kV circuit or segment SK13 which generally follows the Pacific Northern Gas pipeline through the Lachmach and Prudhomme valleys.

Segment SK13 is preferred on technical grounds, particularly for Scheme 1. There are two principal reasons for this. First, segment SK13 is less costly than segments SK11 and SK12 because it would have fewer heavy angle and deadend structures. This is despite the fact that segments SK11 and SK12 have better access. The second reason is that a known ice and wind hazard exists in the area, particularly along segment SK11. The existing lines have been severely damaged by ice loading near Tyee. A route along segment SK13 would separate the lines and therefore provide greater system security, recognizing that segment SK13 is more isolated and also has other terrain hazards.

The remainder of the route between Prudhomme Lake and Rupert substation would follow Highway 16 and the existing circuits. (Segment SK14)

The approximate length of the Skeena River route via segment SK13 is 125 km.

The Douglas Channel route originates at Kitimat substation and follows the west side of Douglas Channel to the Quaal River and then along the Quaal and Ecstall rivers to the mouth of the Skeena River. It follows Highway 16 to Rupert substation along Skeena River route segments SK12 and SK14. The total route distance is 162 km.

The Skeena River route is 37 km (23%) shorter than the Douglas Channel route and generally traverses easier terrain. Approximately 90 percent of the Douglas Channel route can be

classified as rough to very rough whereas only approximately 60 percent of the Skeena River route can be classified the same.

The major difference aside from length between the two routes is the access. Approximately 50 percent of the Skeena River route has reasonably good access either from highway 16 or logging roads. Access road construction along most of the remainder would be very difficult. However, materials and equipment can generally be brought within a few kilometres of these sections where other means of transportation such as barge or helicopter can be utilized.

The Douglas Channel route has no existing access except for the 34 km section between Tyee and Rupert substations. This section is common to both routes. The remainder of the route is extremely isolated. Access to the general vicinity of the route between Kitimat and Kitkiata Inlet and between Falls River and Tyee would probably be by barge only. However, access road construction to the line from the barge landing sites would be very difficult. Also a major road in difficult, swampy terrain would probably be required for the 40 km section between Kitkiata Inlet and the Ecstall River estuary.

As for clearing, both routes would have a significant amount of hand clearing, however, the total amount of clearing required for the Skeena River route would be far less. This is due to the differences in length and the fact that large portions of the Skeena River route parallel the existing line thus reducing the amount of clearing required considerably. Also, major portions of the Skeena route have been logged.

The special considerations for both routes would be approximately similar. Both have a number of major water crossings, require hazard protection devices and have large sections of very swampy ground requiring pile foundations. However, a major consideration

is the probable need to relocate large portions of the Falls River 69 kV line along the Douglas Channel route. This would be costly and difficult because of the extremely restrictive terrain.

It is very difficult to provide an overall hazard comparison for both routes. Both have large sections of very hazardous terrain. There are more areas of high avalanche hazard along the Skeena River route. However there is one particularly difficult section along the Douglas Channel route where avoidance of or protecting against avalanches would be very difficult. This is between Johnston Lake and Falls River.

The landslide and debris flow hazards for both routes are quite similar. The rockfall hazard is probably higher for the Douglas Channel route particularly along the eastern shore of the Ecstall River.

The Skeena River route has an overall higher rating for flood and river erosion because major portions of the route are located on the Skeena River floodplain.

The Douglas Channel route has a higher ice and wind loading hazard because of its exposure along Douglas Channel which is noted for its extremely high winds.

A final consideration in the hazard evaluation is that because the Douglas Channel route is extremely isolated and weather conditions are known to be severe an outage along that route would be very difficult and time consuming to repair.

Based on this evaluation the Skeena River route is technically and economically superior to the Douglas Channel route.

6.2 RECOMMENDATIONS

(a) Scheme 1

The Skeena River route is recommended as the most technically suitable route for a 500 kV scheme between Skeena substation and Rupert substation. More specifically, it is recommended that segments SK1, SK3, SK4, SK6, SK7, SK8, SK10, SK13 and SK14 comprise this route as indicated on Fig. 6-1.

The cost of a 500 kV line along the Skeena River route with a 1988 in-service date would be approximately $140.0 million [including inflation, corporate overhead and interest during construction].

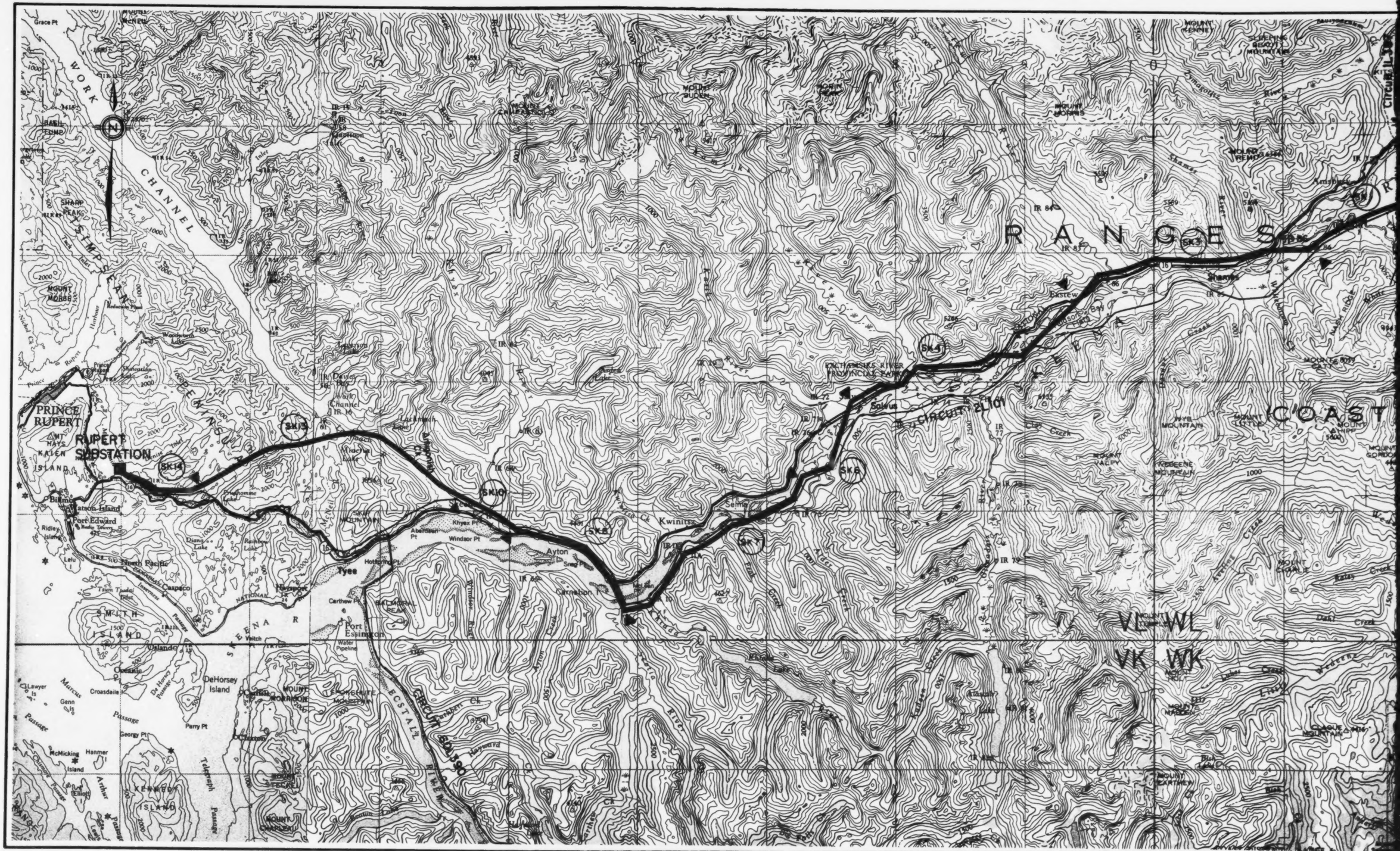
The Douglas Channel route is not practical for a 500 kV scheme primarily because a 500 kV source is not presently available at Kitimat. The nearest 500 kV station to Kitimat is Skeena approximately 50 km to the north. A route from Skeena to Rupert via Kitimat, Dougas Channel and the Ecstall River would be approximately 70% longer than a route via the Skeena River Valley.

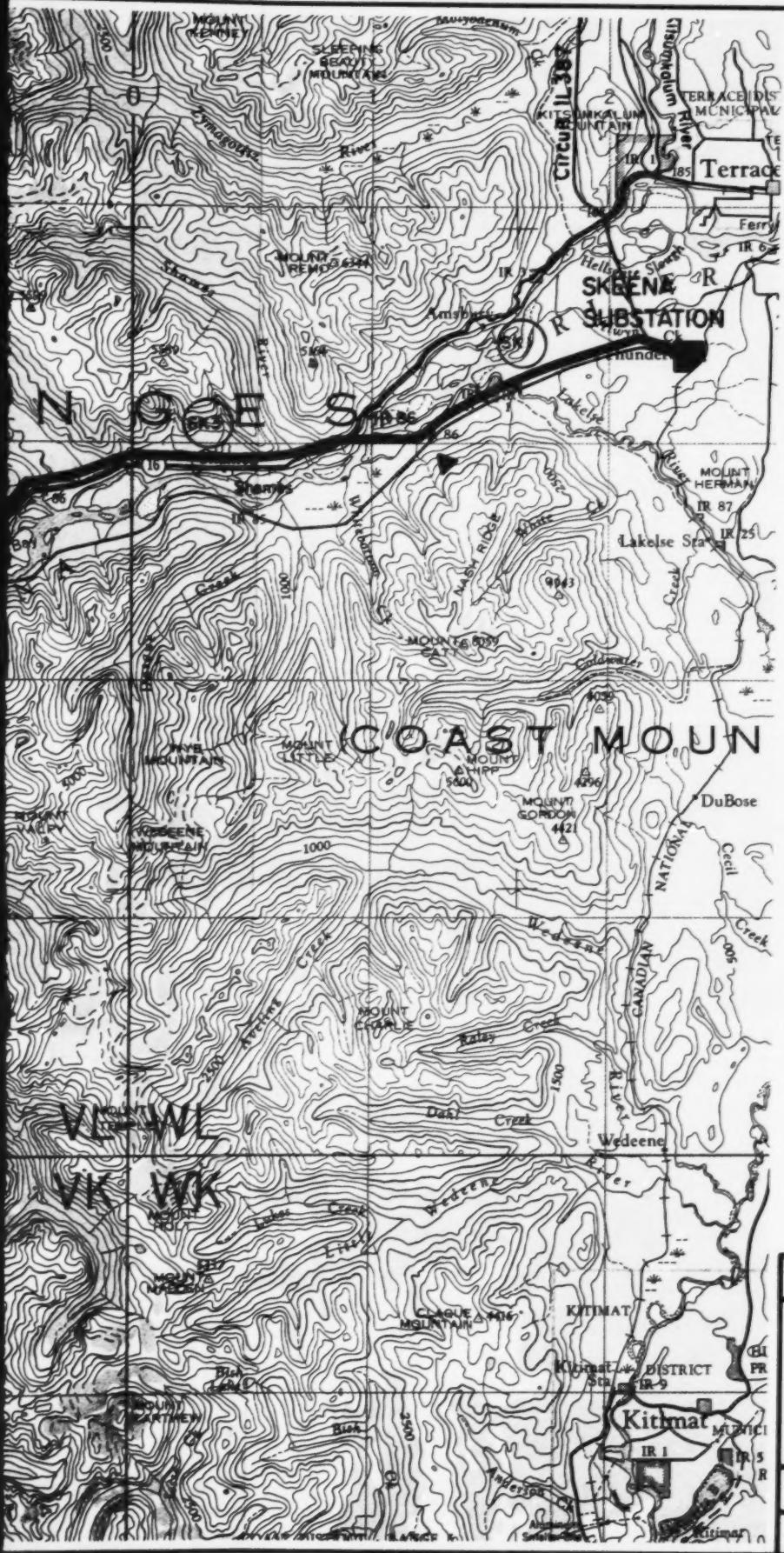
(b) Scheme 2

Both the Skeena River and Douglas Channel routes are recommended for a 287 kV scheme based on the routes studied in this report. The initial 287 kV line should be built along the same set of segments recommended for the 500 kV scheme. The additional 287 kV line proposed for this scheme in the 1990's could follow the Douglas Channel route and segments SK12 and SK14. It would be very difficult to locate this line in the Skeena River valley because of the restrictive terrain and the high number of existing linear developments. However, this is based purely on the obvious difficulties in even locating a second transmission line in the Skeena Valley as outlined in this report. It should be noted that

this study did not specifically address the possibility of a third 287 kV line in the Skeena Valley.

The estimated cost for a 287 kV line along the Skeena River route with a 1988 in-service date would be $93.7 million [including inflation, corporate overhead and interest during construction]. The total cost for a 287 kV line along the Douglas Channel route with a 1997 in-service date would be approximately $295.9 million [including inflation, corporate overhead and interest during construction].


PRINCE RUPERT
RUPERT SUBSTATION
SK1
SK2
SK3
SK4
SK5
SK6
SK7
SK8
SK9
SK10
SK11
SK12
SK13
SK14
WORK CHANNEL
CHATHAM SOUND
SMITH ISLAND
KENNEDY ISLAND
DeHORSEY ISLAND
PORTLAND CANAL
PORT EDWARD
Tyee
Ayton
Kwinitsa
Port Essington
Exstew
Skeena
Zymagotitz
Kitsumkalum
Kitsumgallum
Circuit 2L101
Circuit 2L102
Circuit 2L103
Circuit 2L104
Circuit 2L105
Circuit 2L106
Circuit 2L107
Circuit 2L108
Circuit 2L109
Circuit 2L110
Circuit 2L111
Circuit 2L112
Circuit 2L113
Circuit 2L114
Circuit 2L115
Circuit 2L116
Circuit 2L117
Circuit 2L118
Circuit 2L119
Circuit 2L120
Circuit


Terrace
SKEENA SUBSTATION
Kitimat
DuBose
Wedeene
Lakelse Sta
COAST MOUN
MOUNT HERMAN
MOUNT GORDON
MOUNT CLARKE
CLAGUE MOUNTAIN
KITIMAT
DISTRICT
Kitimat Sta
IR 1
IR 87
IR 25
Lakelse River
Wedeene River
Kitimat River
Skeena River
Zymagotitz River
Kitsumkalum River
Thornhill Mountain
Hell's Gate Slough
Amsbury Creek
Caldwater Creek
Cecil Creek
Ashlu Creek
Ratsy Creek
Dash Creek
Lakes Creek
Tatlessen Creek
Nash Ridge
Circuit 1L 305
CANADIAN NATIONAL
MOUNT KENNEY
SLEEPING BEAUTY MOUNTAINS
MOUNT REMO 6344
MOUNT LITTLE
MOUNT CHIPP 5600
MOUNT CATT 6059
MOUNT TREMBLEUR
MOUNT MATHEW
MOUNT GARTHNEY
WEDEENE MOUNTAIN
KYTE MOUNTAIN
MOUNT LACEY
TERRACE DISTRICT MUNICIPAL
Ferry
IR 6
IR 185
IR 1
IR 5
IR 9
IR 86
IR 87
IR 25
5568
5600
9843
4421
4406
4296
5000
1000
1500
2000
2500
3000
3500
4000
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
13500
14000
14500
15000
15500
16000
16500
17000
17500
18000
18500
19000
19500
20000
20500
21000
21500
22000
22500
23000
23500
24000
24500

APPENDIX I

DESIGN AND CONSTRUCTION PROCEDURES

APPENDIX I
DESIGN AND CONSTRUCTION PROCEDURES

I.1 GENERAL

The following design and construction procedures have been determined primarily for 500 kV construction. However, the procedures and equipment are very similiar for 287 kV construction.

I.2 SURVEY

To determine the feasibility of a particular route, a centreline survey is sometimes necessary. This may be required before the route has been approved or a precise alignment established.

This survey is performed in three main stages. The first stage is the establishment of horizontal and vertical ground control which is done after a detailed route has been selected and approved. Control can be established either photogrammetrically or conventionally whereby the coordinates of the main deflection points along the alignment are determined and established in the field.

After the route has been selected and approved, engineering survey can start.

The second stage involves the cutting of a centreline along the proposed route and the production of a profile along the centreline. Access to the line by the survey crews would generally be by road, where available, otherwise by helicopter.

The final stage in the engineering survey would be the establishment and staking of the individual structure sites. This would be performed after the line has been designed and the location, type and height of the structures has been determined.

I.2 ACCESS

The subject of access is best described in the B.C. Hydro Engineering Standard No. ES-41-E0001-01-R00 titled "Transmission Line Right-of-Way Access Policy." The following is a summary of this standard:

The intent is to supply access at the lowest possible cost with a minimum of ground disturbance for logging, clearing, construction and maintenance of a secure transmission line system. Other possible uses of the access system are secondary.

In assessing the access requirements of the project the following items are taken into account:

1. Type and location of structures.
2. Terrain and soil conditions.
3. Land ownership and the rights of holders of lesser interests in land.
4. Presence, or otherwise, of merchantable timber.
5. Planned future development within the right-of-way.
6. Externally imposed requirements.

The development of access will also be carried out to meet environmental constraints identified for the project.

Existing ground access including possible improvement will be evaluated, possible locations for new access will be investigated and a strategy will be developed to ensure that appropriate access is established for the project.

Machine cleared right-of-way prior to seeding. Note merchantable timber piled for later removal.

Access will usually be by ground means. Aerial and water access will be considered in special circumstances.

The standards pertaining to access construction will be specified in clearing and construction contract documents.

I.3 CONSTRUCTION PROCEDURES

(a) Logging and Clearing

The first major step in the preparation of the right-of-way on Crown land may be the logging of timber deemed merchantable by the Ministry of Forests (MOF). The logging operation and specific logging requirements are controlled and administered by the MOF and are carried out by logging companies. The logging generally requires the construction of logging roads and landings.

When the logging is completed the clearing operation begins. This involves removing the remaining forest cover which could be a hazard to the transmission line. The amount and width of clearing is determined by slope, conductor height, species and growth rates of the forest cover. For example, in areas with short, slow growing trees the clearing boundaries may be inside the legal right-of-way boundary. In areas with tall timber and steep side slopes the clearing boundary may be outside of the right-of-way. In some areas where the conductor is well above the average tree height, particularly across gullies and streams, no clearing is required. Some topping of trees in selected areas may also be carried out. In areas of recent logging activity very little or no clearing is usually required.

The methods to be utilized during the clearing operation are specified by B.C. Hydro in accordance with the land owner or Crown. The methods vary depending on terrain, slope stability, erosion potential and proximity to environmentally sensitive areas.

In areas near swamps, watercourses or on steep slopes where there is a high erosion potential, which would be increased by the use of motorized equipment, clearing is accomplished by hand held equipment. In these areas all taller trees are felled. Conifers less than 2 m in height and low growing vegetation which will not grow to 5 m at maturity are not cut. The larger trees are limbed and left lying flat on the right-of-way. Material under 15 cm diameter is piled and burned.

In areas which require hand clearing due to their sensitivity but also require that large debris be removed because of aesthetics, possible watercourse pollution or fire hazard, the larger material is removed using cable yarders, rubber-tired grapple loaders or rubber-tired skidders.

In areas which have a gentle slope, good drainage and stable soil conditions, clearing is accomplished by grubbing all brush and trees under 60 cm in diameter by bulldozer or similar equipment. Trees larger than 60 cm in diameter are hand felled. The waste material is piled and burned.

In areas where there have been specific requests by owners for stump removal and right-of-way grooming, and where there is no erosion potential, all the waste material may be removed by bulldozer.

Photo A-2

The installation of an earth grillage with a hydraulic back hoe on right of photo. A tank drill drilling for a rock foundation on the left.

(b) Foundation Installation

After the right-of-way has been cleared and the structures staked, foundation installation begins. Depending on schedule, working conditions and number of crews, foundation installation can begin at various points along the line. Separate crews are generally used for access road construction, site preparation and for the different foundation types to be installed e.g. earth grillages, rock footings, piles, etc.

The first step in the foundation installation is site preparation. Major equipment used for this operation are crawler equipped bulldozers and backhoes.

After the site has been prepared, excavation for grillage foundations is done by rubber-tired or crawler equipped backhoes. Crawler equipped tank drills, compressors and hand held rock drills are used for drilling rock anchors and for blasting shallow depth rock at grillage sites.

Components for grillage foundations are usually stored and assembled at temporary yards set up along the length of the line. The assembled grillages are then delivered to the site, positioned in the excavation, and the earth backfilled and compacted around them.

Rock and concrete footings are constructed on site. Concrete for the footings can be made at portable batch plants set up along the route or purchased from local suppliers.

Pile foundations, which are most often required in wet and swampy ground, are large and require heavy equipment for installation. The major components are timber piles capped by concrete. The piles are driven with large truck-mounted or crawler cranes equipped with leads and drop hammer.

Photo A-3

A self supporting structure being erected by a crane.

Construction materials are delivered to the site by various means. Flat bed trucks are utilized for transporting assembled grillages, other foundation components and equipment. Concrete may be delivered by large transit mix trucks.

Foundation materials, concrete, small equipment and construction crews can be transported to otherwise inaccessible sites by helicopter. The maximum weight normally lifted by the largest, readily available helicopters in Canada is in the order of 2300 kg depending on elevation, weather conditions and distance from assembly area to work site. For example this would limit a single load of concrete to approximately 1 m^3. Equipment required for site preparation often has to be disassembled to permit transportation by helicopter. For these reasons helicopter operation is usually not economical for foundation installation.

(c) Tower Erection

The next major phase of transmission line construction is tower assembly and erection. Depending on scheduling and other factors, this phase of the work may or may not be carried out by the same contractor who installed the foundations. Nonetheless, the two operations are usually carried out separately.

The first step in tower erection is the local improvement of access and work areas at individual tower sites to handle the different types of equipment used for tower erection.

Tower steel is delivered to temporary steel yards established at the nearest rail siding, highway or road access along the route. The steel is then sorted and distributed to the tower sites by various means, the most common of which is crane equipped, flat-bed trucks.

Photo A-4

Structure erection utilizing a helicopter.

Tower components are generally assembled on site by crews working ahead of the tower erection crews. The tower components are assembled utilizing 15 to 20 t cranes.

Tower erection is carried out by use of large truck-mounted hydraulic cranes which have capacities of 35 to 65 t. Cranes of this size are cumbersome and thus require bulldozers to aid in manoeuvring and for preparation of working areas.

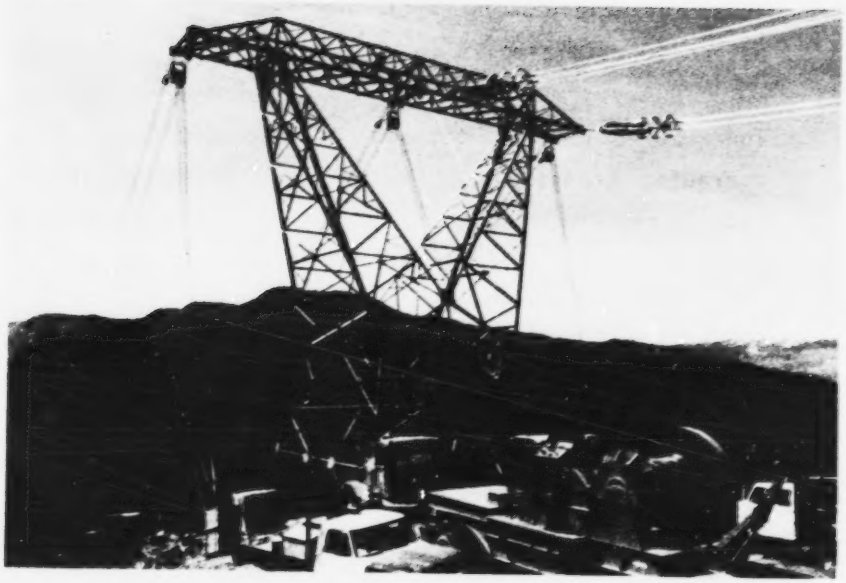
Tower erection on difficult or environmentally sensitive areas can be accomplished by helicopter but this method has similar limitations as discussed earlier for foundation installation.

The main limitation to helicopter erection is the weight of the towers. The towers to be used on the project weigh between 4 000 and 35 000 kg. Whole towers cannot be erected with a single lift. Individual tower components must be assembled and flown into place component by component. To optimize the economics of this operation, assembly yards would be placed at 10 to 15 km intervals along the route where assembly can be accomplished by conventional means for later delivery to the tower site by helicopter. Assembly yards should be accessible by road. Regular spacing of assembly yards along the route is required to minimize the flying time to the individual tower sites.

Weather conditions, helicopter availability, economies of scale (i.e. number of towers to be erected) are all factors which limit the use of helicopters for tower erection.

(d) Conductor Stringing

Conductor stringing, like foundation installation and tower erection, is usually done under a separate contract. This phase of construction is complex involving stringing, sagging, clipping,



Photos A-5 and A-6

The equipment necessary for conductor stringing.

dead-ending and spacing the conductor.

Large specialized equipment such as line pullers and tensioners are required for the stringing operation. This equipment cannot be lifted by helicopter and requires good road access. However, this equipment is only needed at intervals along the line. The spacing of these "set up" intervals is generally limited by the length and weight of conductor on each reel.

The conductor is pulled between the set ups by first stringing a small diameter line through sheaves on each tower. This operation is usually done by helicopter. This line is then used to install the main pulling line which in turn is attached to the conductor. The conductor in turn is pulled through by the line puller at the destination end. The conductor is kept under tension at the reel end to avoid damage by contact with the ground or obstructions.

After the conductor has been strung it is sagged to a specified tension and connected to the insulator assembly on the tower.

Cranes, forklifts, specially equipped caterpillars and all-terrain vehicles are used for handling materials, hanging insulator assemblies and other stringing operations. Material yards are established at various intervals along the route.

(e) Office and Accommodation

Temporary office facilities and construction camps may be required at intervals along the route where access is poor to minimize travel time to and from the work sites.

The specific size, type and location of the facilities will vary with each phase of construction and will be dependent on the contractor's needs. Commercial facilities will be used wherever practicable.